THE UNIVERSITY OF ALBERTA

RELEASE FORM

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TITLE OF THESIS Multistage Remote Sensing with Grade Four Students

DEGREE FOR WHICH THESIS WAS PRESENTED Master of Education

YEAR THIS DEGREE GRANTED 1984

MULTISTAGE REMOTE SENSING WITH GRADE 4 STUDENTS

by

©

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF Master of Education

DEPARTMENT OF ELEMENTARY EDUCATION

EDMONTON, ALBERTA

Fall, 1984

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Multistage Remote Sensing with Grade 4 Students" submitted by Pearl Anjanee Gyan in partial fulfilment of the requirements for the degree of Master of Education.

AFFECTIONATELY DEDICATED

To my daughter, Aum, my son, Atma, and children everywhere

Earth is your school
Tuition is free
Reach for the stars

KEYWORDS AND ABSTRACT

KEY WORDS: Aerial photographs; Aerospace education; Color infrared vertical aerial photographs; Elementary education; Earth science; Grade four students; Geography; Image interpretation; Landsat imagery; Land cover studies; Land use studies; Maps; Mapping; Multistage sensing; Planetary science; Remote sensing education; Road map; Satellite imagery; Social studies; Space education.

ABSTRACT: Multistage remote sensing makes use of a combination of spacecraft, aircraft, and ground-derived data for assessing and monitoring the Earth's resources. The use of some of these materials in elementary education has been primarily with black and white vertical aerial photographs and Landsat C1 imagery. This exploratory study reports on the ability of grade four children to interpret color infrared vertical aerial photographs and use them in conjunction with a road map and Landsat C1 imagery, each of the same site. This information is necessary for determining the use of these materials in the classroom for obtaining current and significant geographic information about the Earth and its resources.

The investigation was done through the use of a constructed instrument -- the Remote Sensing Oral Achievement Test Battery (RSOATB). It consisted of a battery of questions that dealt with

three levels of image discrimination: (a) detection, (b) identification, and (c) analysis; and two methods for image observation: (a) the non-directed, and (b) directed methods. The Ishihara Test was used to determine the children's color vision.

The sample consisted of children from an Edmonton elementary school in the city of Edmonton. Since the children's IQ and reading scores could not be made available, the classroom teacher was requested by the investigator to group the class in the categories: above average, average, and below average. Two children in each category were randomly selected by the investigator, totalling a population of six subjects, two females and four males.

The main findings of this study were as follows:

1. These children can interpret a city road map.

2. The road map appears to be a satisfactory tool for obtaining secondary ground truthing information.

3. High altitude, small scale and low altitude, large scale color infrared vertical aerial photographs can be interpreted by these children.

4. These children can handle a multistage remote sensing approach using a road map, CIR vertical aerial photographs, and Landsat C1 imagery each representing the same site.

5. The non-direct method of observation seems useful for detection, while the direct method provides better guidance at the identification and analysis levels of image discrimination.

6. The proportion to which map interpretation elements namely: color, shape, size, texture, pattern, shadow, site, and association are used, depends on which category (cultural, vegetational, physical, geological, or hydrological) the question relates to.

7. There seems to be no preference by these children for selecting features in the categories of: cultural, vegetation, physical, geologic, or hydrologic, since this will depend on the question.

8. The male child diagnosed as partially color-blind appears to have had no difficulty with the interpretation of a road map, color infrared vetical aerial photographs, and Landsat C1 imagery.

ACKNOWLEDGEMENTS

I am indebted to my advisor, Dr. J. Kirman for his help, guidance, encouragement, and inspiration so generously given throughout my graduate program and in the completion of this study. I am very grateful.

Thanks are also expressed to my committee members, Dr. Jack Goldberg and Dr. Don Massey for their constructive suggestions.

Appreciation is expressed to the Edmonton Public School Board, the principal and staff at the school used for this study, and especially the grade four children and teacher directly involved. Their excellent co-operation, willing assistance, and amiability made the execution of this project an enjoyable experience.

Sincere thanks are expressed to Mr. Ian Sutherland, Remote Sensing Technician for his assistance in the preparation of the remote sensing test battery and to Mr Ken. Campbell, Mr. Cal Bricker, and Miss Heather Smith, all of the Alberta Remote Sensing Center for their help.

Further acknowledgement is made to Dr. C. Brown, Dr. A. Laycock, and Mr. Jack Park, of the Department of Geography, University of Alberta, for their help with my independent study in remote sensing, and for Mr. Park's assistance in using aerial photographs, and to Mr. Ed. Kennedy, Mapping Director, Alberta Bureau of Surveying and Mapping, for supplying the writer with road maps.

The writer wishes to thank Mr. Glen Carley for proofreading, Miss Shari Narine for her typing assistance, and Mrs. Loraine Funk for her excellent work in the final typing of the manuscript.

Finally, thanks are expressed to my daughter "ohm" for typing seemingly endless pages; to my son "amp" for his understanding, concern, and patience; and to my special friend "g" for encouragement during the completion of this study.

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"... venient annis / Saecula seris quibus
oceanus / Vincula rerum laxet: et ingens /
Pateat tellus: Typhis novos / Detegat orbes:
nec sit terris / Ultima Thule." (There will
come an age in some distant future when the
Ocean shall loosen its shackles and the earth
shall lie wide open; and Typhis .... shall
discover a new world. And no longer shall
there be an end .... to the earth).
Seneca, Medea, Act 11, Scene 2, Line 371.[1]

CHAPTER I

INTRODUCTION

The learning of certain geographic concepts in any social studies program is most often dependent upon the use of maps. Maps when handled, observed, and interpreted by children should provide real-world geographic information, and help develop related mapping skills. The extent to which such information and skills are derived and developed depends very much on the type of map used and the interpreters experience.

One type of map that has been used traditionally in the classroom and is still being used is the topographic map such as is found in some texts and atlases. These maps are further from reality than iconic maps and "exhibit clearly defined limitations," which make them inadequate for learning about the real world.[2]

[1] Thomas Goldstein, Dawn of Modern Science (Boston: Houghton Mifflin, 1980), p. 21.

[2] Philip C. Muehrcke, "Map Reading and Abuse", Journal of Geography, 73 (May, 1974). p. 11.

Through improvements in remote sensing -- the ability to detect the nature or condition of an object without actually touching it -- up-to-date and accurate data of the Earth are presently obtained. Some of this data in the form of photographs and images can be used as maps which children can handle, observe, and learn to interpret. In this study, only those forms of imagery dealing with vertical aerials, color photographs, and Landsat C1 and MSS images are discussed.

Aerial photographs are produced by airborne cameras so that large areas of the Earth can be seen. With improvements in lenses, film and filter combinations, vertical aerial photographs rather than obliques have become acceptable mapping tools for measuring and mapping the Earth's surface, preparing topographic maps, and other remote sensing applications.[3]

The interpretation of black and white vertical aerial photographs is presently applied to agriculture, forestry, geology, land use and land cover mapping, hydrological studies, urban and regional planning, wildlife ecology, and archeology.[4] Researchers in education (Blaut and Stea, Dueck, Kingston, Long, and others mentioned in this study) reveal that black and white verticals can

[3] Thomas M. Lillesand and Ralph W. Kiefer, Remote Sensing and Image Interpretation, (NewYork: John Wiley and Sons, 1979), pp. 77, 98-99.

[4] Lillesand and Kiefer, p. 95.

be used as maps in the classroom for geographic learning.

Color and color infrared vertical aerials and satellite imagery have also become additional tools for mapping activities. Normal color photograph records the colors of the natural scene which we can see, while color infrared photography records some information in the infrared region of the electromagnetic spectrum (EMR) where the human eye cannot see.[5] In this respect, color infrared vertical aerial photographs are considered superior to normal color for recognizing certain vegetation, water, and soil conditions.[6]

Black and white color, and color infrared vertical aerials, and satellite imagery, when used together with topographic maps can increase the amount of information derived. In geographic education, color infrared vertical aerials could be used in such a 'multistage sensing' approach thereby enabling children to obtain more information than they could gather by using only one type of map.

Satellite imagery is a more recent technological development. By a series of Landsat satellites, information about the Earth's

[5] Robert G. Reeves, Ed. Abraham Anson, and David Landen, Manual of Remote Sensing, Volume 11 (Falls Church, Virginia: American Society of Photogrammetry, 1975), p. 932.

[6] Reeves, Anson, and Landen, p. 932.

resources is obtained. Landsat 1, first launched by the National Aeronautics and Space Administration (NASA) in 1972, was followed by Landsat 2, 3, 4, and 5, launched in 1975, 1978, 1982, and 1984 respectively. Landsat 1 and 2 are now retired but their data are still of use.

Each Landsat satellite is equipped with a Multispectral Scanner (MSS) from which most data are derived. The MSS transmits information on four wavelength bands of the EMR to produce black and white MSS images. By using three such images, color composites are generated which simulate the color rendition of color infrared film.[7] Landsat color images and color infrared vertical aerials can therefore be used together for various map interpretations and mapping activities.

Landsat image interpretation is presently being used in the same fields as aerial photographs, as well as in civil engineering, environmental monitoring, land resource analysis, and oceanography.[8] In education research in the use of Landsat Color 1 and MSS images has shown that children as young as grade three can use Landsat Color 1 images for obtaining geographic information.[9]

[7] Lillesand and Kiefer, p. 540.

[8] Lillesand and Kiefer, p. 543.

[9] J. Kirman, "The Use of Infrared False Color Satellite Images by Grade 3, 4, and 5 Pupils and Teachers," The Alberta Journal of Educational Research, 23, No. 1 (1977), p. 63.

In a time of increasing success with space technology, space stations and lunar bases are imminent enterprises for many Earth benefits including information about the Earth and its resources. With present uses of aerial, satellite, and more recent space shuttle sensor systems, a dramatic increase in data about the Earth will become available. If both color infrared vertical aerial photographs and Landsat Color 1 images are included in the social studies program now, more awareness and sensitivity about the Earth and its resources will be developed in children, and, as well, will prepare them to use data provided by future space sensors.

Information about children's ability to use black and white vertical aerials, color photographs, Landsat Color 1, and Multi-spectral Scanner images is available, but there is no data regarding children's ability to interpret color infrared vertical aerial photographs and use them in combination with Landsat Color 1 imagery and a topographic map such as a road map, each representing the same scene.

1. THE PROBLEM

This is an exploratory investigation to find out whether a selected small group of grade four children can interpret color infrared vertical aerial photographs and use them in conjunction with Landsat Color 1 imagery and a road map.

An integral part of the Alberta Social Studies Curriculum is

the acquisition of geographic information from maps. Competency in map reading and map interpretaion from accurate and up-to-date remote sensing sources can provide a greater understanding of concepts related to the Earth, its resources and problems. If topographic maps, color infrared vertical aerials and satellite imagery are being presented in selected social studies elementary school texts, then an investigation is in order to determine whether elementary school children can use CIR vertical aerial photographs and in combination with Landsat C1 imagery and other topographic maps.

Background to the Problem

The geographic content of the 1982 Alberta Social Studies Curriculum includes the teaching of a sequence of map skills from grade one through eleven. As early as grade three, children are expected to gather and organize data by reading and interpreting simple maps to locate information.[10] From grade four on, children are required to read and interpret maps for selected geographic concepts on certain issues.

Of interest to this study is the grade four Topic A unit of the 1982 Social Studies Curriculum prescribed by the government of Alberta. In this study about Alberta, Past, Present and Future: Our Natural Resources students investigate issues pertaining to the

[10] Government of Alberta, 1981 Social Studies Curriculum (Edmonton: Alberta Education, Curriculum Branch, 1981), pp. 26-30.

use the province's natural resources. The unit provides a wide scope for learning geopraphic concepts through map studies which continues into consecutive units in the grade four program as well as in the following grades.

The main sources of map learning material for this unit are the government's published texts, The Junior Atlas of Alberta,[11] and Landscapes of Alberta.[12] Among the contents of these texts are a few color infrared vertical aerial photographs and Landsat Color images of places in Alberta with which children are expected to be familiar. The problem arises as to whether elementary children can interpret color infrared vertical aerial photographs and use them in combination with Landsat Color 1 imagery and a road map for obtaining geographic information. Although the texts noted above are prescribed for use in the social studies program, there are no studies that indicate whether elementary children can interpret color infrared vertical aerial photographs and use them in conjunction with Landsat Color 1 images and a road map.

The combined use of spacecraft, aerial, and ground-observed information or 'multistage sensing' is an approach to mapping which can generate abundant, accurate, and reliable information of almost any area on the Earth's surface. Spacecraft information represents macro environmental features such as biome types, physiographic

[11] Government of Alberta, Junior Atlas of Alberta, (Edmonton: Alberta Education Curriculum Branch, 1979).

[12] Lynda Hoffman and Pat Redhead, Landscapes of Alberta, (Edmonton: Alberta Education Curiculum Branch, 1980).

provinces, regional geologic structures, patterns of human activity, snowline, earth, and water interface.[13] Aircraft imagery also provide environmental features and much more detailed characteristics of physiographic regions, soil types, vegetation specie identification, and land uses.[14] Ground-observed information is derived from field experiences. The road map is placed in the category of ground-observed information because of its simplicity of perspective and pertinent ground information. However, it does not replace field experience.

Early researchers in map studies have stated the significance of using a variety of maps by children.[15] Other researchers in remote sensing have indicated the benefits of using multiple views of the Earth's surface for learning about our natural resources,[16] and according to some of them, multiple viewing can build map

13 Joseph Lintz Jr., and David S. Simonette, Remote Sensing of the Environment (Reading: Addison-Wesley, 1976), p. 107.

14 Lintz and Simonette, p. 107.

15 See, for example, Marguerite Logan, "Pictures as Geographic Tools," National Education Association Journal, 39 (Jan., 1950), p. 46; Edna S. Mitchell. "Introducing Maps - A Skill," Childhood Education, 37 (Feb., 1961) pp. 282-283; Paul D. McDermott, "Geography Graphics," Journal of Geography, 68 (Sept., 1969), p. 336; Field Study for Remote Sensing: An Instructors Manual, Proc. of the Landsat C Educator's/ User's Workshop, eds. William H. Wake and Garth A. Hull, 2-4 March 1978 [Washington, D.C.: Government Printing Office (GPO)], 1981, pp. 11-13; Robert C. Kingsbury, "Comparing Maps with Aerial Photographs," Journal of Geography, 68 (Oct., 1969); Donald O. Bushman and Richard G. Silvernail, "Terrestrial, Aerial, and Satellite Photographs," Journal of Geography, 69 (May, 1970).

16 Lillesand and Kiefer, pp. 30-31; and Lintz and Simonette, pp. 105-116.

interpretation skills.[17]

Dueck's study reported on grades four, five, and six children's use of black and white vertical aerial photographs.[18] Kirman has examined grades three through six children's use of Landsat C1 images which have an infrared false color.[19] It can therefore be hypothesized that if a combination of color infrared vertical aerial photographs, a Landsat C1 image, and a road map were to be used by children information may be derived that can be useful for understanding geographic concepts about the Earth and its resources. To determine whether grade four children can interpret color infrared vertical aerial photographs and use them in conjunction with Landsat Color 1 imagery and a road map, each representing the same scene, a preliminary investigation was required.

III. LIMITATIONS

The following factors may limit the generalizability of this research.

[17] Wake and Hull, p. 11.

[18] K.B. Dueck, "Reading and Interpreting Photographs in the Intermediate Grades," Unpublished Master's Thesis, University of Calgary, 1969.

[19] Kirman, 1977; J.M. Kirman and J. Goldberg, "Student Teacher Telephone Conferencing with Satellite Maps as a Monitoring Device," The Alberta Journal of Education Research, 25 (Dec., 1979), pp. 275-283.

1. Generalizations based on the results of the research are limited due to the size of the sample chosen and the criteria for choosing them.

2. This research is confined to a sample of urban children upon which generalizations may not pertain to rural children.

3. This research is confined to reading and interpreting the materials used in this project.

IV. ASSUMPTIONS

Research in the use of iconic representation by young children had demonstrated that mapping is a natural part of human development.[20] Accordingly, such tools that can stimulate this growth should be used by children in the classroom, and as well, relevant map skills applied to facilitate this learning.

If it is found that grade four children can read and interpret color infrared vertical aerial photographs and use them in conjunction with Landsat Color 1 imagery and a road map, the following may be of significance.

1. The use of these materials in the classroom,

[20] J.M. Blaut, "Studies in Developmental Geography," Report No. 1 Clark University, 1969, p. 19.

2. Inservice for teachers in the use of these materials.

3. The preparation of a remote sensing supplemental kit for use with map learning in the elementary grades social studies curriculum.

4. Curriculum planning, taking into account the use of remote sensing materials for the study of geographic and environmental learning, and the study of aerospace activities as related to the elementary curriculum.

5. Dealing with skills for use with maps described in this study.

VI. DEFINITION OF TERMS

aerial photograph - a photograph taken with a camera from the air.

analysis - the ability to go beyond the identification of the object and to use acquired data in the solution of the problem at hand.

color - that property of an object which is dependent on the wavelength of the light which it reflects or, in the case of a luminescent body, the wavelength of light it emits ... white light is a balanced mixture of all the visible spectral colors.[21]

[21] Reeves, et al. p. 2073.

Color 1 (C1) - a composite Landsat image formed by Band 4 printed in blue, Band 5 printed in green, and Band 7 printed in red. Band 4: recording in the blue/green portion of the visible spectrum lying between .500 and .600 micrometers (μm) in wavelength. Band 5: recording in the red portion of the visible spectrum lying between .600 and .700 (μm) in wavelength. Band 7: recording in the near/medium infrared portion of the spectrum well beyond visible range, and lying between .800 and 1.100 (μm) in wavelength.

cultural features - all works of man shown on a map, photograph and image.

detection - the ability to visually estimate objects or features upon examination of the map, photograph, or image dependent on the interpreter's experience and/or field or knowledge.

directed observation - guiding the subjects by means of questions or cues to interpret an image:[22] For example, point to a target and ask; what is this?

electromagnetic spectrum - the ordered array of known electromagnetic radiations extending from the

[22] Dueck, p. 5.

shortest cosmic rays . . . to the longest radio waves.[23] Hereinafter referred to as EMR.

ground truthing - field work involving on-site investigation.

hydrological features - water-bodies that are natural or man-made, and perceived from information present on the map, photograph, or image.

iconic map - pictorial representations of the Earth's surface. (See definition for 'map').

identification - the ability to identify objects or features perceived fom information present on the map, photograph or image.

image - a photographic-like representation of an object or the Earth's terrain generally acquired through electronic means as from a space satellite.

image interpretation - the act of examining photographic images for the purpose of identifying objects and judging their significance.[24]

infrared (IR) - the portion of the electromagnetic spectrum with wavelengths just beyond the red end of

[23] Reeves, et al. p. 2080.

[24] Dueck, p. 5.

the visible spectrum. Hereinafter referred to as IR.

Landsat - an Earth resources satellite viewing almost every point on the Earth's surface every 18 days (Landsat 1-3) or 16 days (Landsat 4 and 5).

map - "a representation in a plane surface, at an established scale, of the physical features (natural, artificial or both) of a part or all of the Earth's surface with the means of orientation indicated."[25]

Multispectral Scanner (MSS) images - a Landsat sensor system recording in four wavebands simultaneously -- green (0.5 to 0.6 μm), red (0.6 to 9.7 μm), and two in the near IR (0.7 to 0.8 μm and 0.8 to 1.1 μm). The resulting MSS images are black and white, and correspondingly designated as band 4, 5, 6, and 7 from which color composites are generated.

micrometer (μm) - one millionth of a meter. "The unit (1 x 10^{-6}) is used to measure wavelength along the spectrum. Wavelength being the distance from one wave peak to the next."[26] Hereinafter referred to as μm.

25 Reeves, et al. p. 2091.

26 Lillisand and Kiefer, p. 4.

multistage sensing - the combined use of data collected from multiple altitudes of the same scene, e.g. a low flight photograph, a high flight photograph, and a Landsat image.

non-directed observation - general detection of an image in which the child is simply asked, "what do you see?"

photograph - a picture formed by the action of light on a sensitized surface or material such as film.

remote sensing - the science and art of detecting the nature or condition of an object without touch or direct contact.[27]

scale - the relation between the distance on a map, photograph, or image and the corresponding distance on the ground. The larger the denominator of the fraction, the smaller the scale of the representation.

vertical aerial photograph - a photograph taken with the camera axis directed as vertically as possible along flight lines of an airplane.[28]

[27] Lillesand and Kiefer, p. 1.

[28] Lillesand and Kiefer, p. 67.

VIII. ABBREVIATIONS FOR SELECTED TERMS

Color infrared	CIR
Color Infrared Vertical Aerial Photograph	CIRVAP
Electromagnetic Spectrum	EMR
Infrared	IR
Landsat Color 1 image	Landsat C1
Large Scale, low altitude, color infrared vertical aerial photograph	Map 2
micrometer	μm
Remote Sensing Oral Achievement Test Battery	RSOATB
Remote Sensing Teaching Unit	RSTU
Small scale, high altitude color infrared vertical aerial photograph	Map 1

VIII. SUMMARY

The purpose of this chapter has been to introduce the application of remote sensing materials, such as color infrared vertical aerial photographs and Landsat C1 imagery, to accompany topographical material such as a road map for learning geographic concepts. These materials are presented in recommended texts for the elementary school's social studies program. However, there are no indications from these texts or other sources to show that elementary children can use color infrared vertical aerials in combination with Landsat C1 imagery and a road map of the same scene.

The use of topographic maps alone still persist in the classroom, but these maps are insufficient for learning about the real world. Vertical aerials and Landsat imagery are iconic aerial and satellite-derived data that accurately depict the Earth's surface. They are closer to reality than topographic maps. Landsat C1 imagery approximates the colors and shades of color infrared vertical aerial photographs so that when used together they increase information about the Earth and its resources.

According to the government of Alberta's Social Studies Program, grade four children are required to learn specific concepts about Alberta and its resources and are expected to use maps for such geographic learning. A variety of maps, aerial photographs, and satellite imagery could provide abundant, accurate and current information.

Accordingly, this study investigates whether grade four children can interpret color infrared vertical aerial photographs and use them in combination with Landsat C1 imagery and collateral data such as a road map.

CHAPTER II

REVIEW OF THE LITERATURE

This chapter contains a review of literature related to this study. An examination of the literature indicated that no studies had been done concerning the use of color infrared vertical aerial photographs by elementary or secondary students. Consequently, literature related to children's abilities to use maps, road maps, black and white vertical aerial photographs, and Landsat Color 1 Imagery were examined.

The literature reviewed, discussed, and summarized deal with the use of:

1. Maps in the elementary grades.
2. Road maps in the elementary grades.
3. Aerial photographs in the elementary grades.
4. Landsat Color 1 Imagery in the elementary grades.

1. Maps in the Elementary Grades

The numerous sources of literature in geographic education reveal the use of maps and the development of map skills with children. From as early as grade one, map studies, however

minimal, are recommended in some social studies curricula.[1] The use of maps as a tool is considered fundamental to geographic education. First, they organize geographic information in a graphic form. Second, they show the spatial allocations, aerial distribution and densities of both cultural and physical phenomena.[2]

Sabaroff discusses maps as a "shorthand record of a mass of geographic knowledge" which, when used in the classroom, attempts to help children learn about the environment and man's relationship with it.[3]

Various research in map studies reveal that even very young children have mapping abilities. Whitemore explains that "children will begin early and without direction to represent places they have seen by reproducing with blocks."[4]

[1] Government of Alberta, 1981 Social Studies Curriculum Edmonton: Alberta Education, Curriculum Branch, 1981, pp. 18 - 20.

[2] R.P. Hanna, R.E. Sabaroff, G.E. Davies, and C.R. Farrar, Geography in the Teaching of Social Studies, (Boston: Houghton Mifflin, 1966), p. 16-17.

[3] Rose Sabaroff, "Improving the use of Maps in the Elementary School," Journal of Geography, 60 (April, 1961), p. 184.

[4] In, Harriet Chace, "Developing Map Skills in Elementary School," Social Education, 19 (Nov., 1955), p. 310.

Blaut's study on toy-play mapping reveals that "as young as age three, the child is already a map maker."[5]

To an observer of the environment, the view of the world is often limited to his field of vision. In geographic learning, the child's view of the world is also limited to his field of vision. Even relatively small parts of the Earth's surface are beyond the range of the child's sensory experience.[6] In such cases maps have to be relied on.[7] Kohn explains that:[8]

> Maps are graphic reduction of a portion or all of the Earth's surface which in itself does not present a difficult problem in map reading, for the human mind accepts readily many reductions without hesitation. The difficulty with most maps is that their graphic representation in a reduced form is an abstraction because it cannot be related to any such experience.

These graphic representation or symbols, described by various writers as the "map's language" are what children are expected to read and interpret with the aid of a map skills program.

[5] J.M. Blaut and David Stea, "Mapping at the Age of Three," Journal of Geography, 73, No. 7 (Oct., 1974), p. 9.

[6] Clyde F. Kohn, "Interpreting Maps and Globes," Twenty Fourth Yearbook, ed. Helen Carpenter (Washington: National Council for Social Studies (N.C.S.S.) 1953), p. 151.

[7] Roger A. Hart, "Aerial Geography: An Experiment in Elementary Education," Place Perception Research Report Number 6. Unpublished Master's Thesis, Clark University, 1971, p. 7.

[8] Kohn, pp. 151 - 152.

One basic set of map skills Kohn has developed can be adapted to any grade level. It is as follows:[9]

1. The ability to orient the map and the ability to note direction.
2. The ability to recognize the scale of a map and compare distances.
3. The ability to locate places on maps and globes by means of the grid systems.
4. The ability to recognize and express relative locations.
5. The ability to read symbols and look through maps to see the realities for which the symbols stand.
6. The ability to correlate patterns that appear on maps and make inferences concerning the association of people and things in particular areas.

Most of these basic skills involve the mathematical calculations of scale, distance, and grid systems (measurements). Taking into consideration these concepts, as well as other map-related developmental characteristics such as an external frame of reference, spatial orientation, manipulation, and symbolization, Meyer proposes an alternative sequence of map skills instruction that leads to the gradual development of orientation and measurement.[10]

[9] Kohn, pp. 146 - 174.

[10] Judith Meyer, "Map Skills Instruction and the Child's Developing Cognitive Abilities," Journal of Geography, 72 (Sept., 1973), pp. 27 - 35.

They are as follows:[11]

1. The ability to make a map.
2. The ability to "read" or get information from a map.
3. The abilitiy to interpret the information presented by a map.

It appears to emphasize that the main purpose of map interpretation is to obtain geographic information, rather than to deal with measurement concepts which 'various reports' show, young children find difficult.[12]

Other studies report on ways basic map skills could be developed with children. For example, Kohn points out that "the first step in teaching children to read the language of maps is to provide either real or vicarious contacts with the physical and man made features for which the symbols stand."[13] Sabaroff also suggests first-hand experiences with the real world.[14]

[11] Meyer, p. 31.

[12] Meyer, p. 28. Her reference to Piaget's studies of the child's conception of space, and Towler's investigation on the child's concept of reference systems.

[13] Kohn, p. 166

[14] Rose Sabaroff, "Using Maps in the Second Grade," Journal of Geography, 57 (Nov., 1958), p. 410.

Mitchell stipulates that, "no map can show the curvature of the Earth and be completely accurate."[15] Therefore, both she and Bartz point out the significance of using a variety of maps which they specify should be cartographically accurate and contain up-to-date information.[16]

Most of these writers discussed the development of map skills using conventional topographic maps which "still retain limitations of projection, scale, and graphic symbolization."[17]

To coalesce the use of different scales (reduction), overhead projection (rotation), and symbolization (abstraction) difficulties encountered in using topographic maps - Blaut experimented with young children using iconic representation such as the aerial photograph.[18] Blaut and Stea later theorized that "when the ability to interpret maps is developed, then the writing and arithmetic of map legend and scale could be handled."[19]

[15] Edna S. Mitchell, "Introducing Maps - A Skill," Childhood Education, 37 (Feb., 1961), p. 283.

[16] See, Mitchell, p. 282 - 283 and Barbara Bartz, "Maps in the Classroom," Journal of Geography, 69 (Jan., 1970), pp. 18 - 24.

[17] Phillip C. Muehreke, "Map Reading and Abuse," Journal of Geography, 73 (May, 1974), pp. 11 - 22.

[18] J.M. Blaut, "Studies in Developmental Geography," Place Perception Research Reports, No. 1. Clark University (Oct., 1969), p.14.

[19] J.M. Blaut and David Stea, "Studies in Geographic Learning," in J. Bale, N. Graves, and Rex Walford, Perspectives in Geographic Education, (Birkenhead: Oliver and Boyd, 1976), p. 97.

Thus, it may be implied that the use of conventional topographic maps such as wall maps, globes, and those in books and atlases used in the classroom do not provide further challenges in geographic learning besides the map skills shown earlier by Kohn. Nevertheless, in the development of map materials for classroom use and map skills instruction, conventional topographic maps have been the earliest tools for children to use in learning about environmental geography, and acquiring some mapping skills and concepts.

Only two sources of literature directly relating to conventional topographic maps used in the elementary classroom were discovered by the writer.

Brown and others wished to determine the relationship between map problem difficulty and students' acquired level of intellectual development, and the effects of sequential mastery of map concepts in the geography curriculum.[20] These investigators examined boys and girls, aged 8 - 15 years. Their map materials consisted of four ordinance survey maps and two school atlases.

Brown concluded that:[21]

> Eight years olds can understand conventional signs and direction questions; at the age of about nine or ten, the

[20] T.W. Brown, et al. "An Investigation into the Optimum Age at Which Different Types of Map Questions May Best be Set to Pupils in the Teaching of Geography," pp. 1 - 39. Proc. of a Meeting by the Commission on the Teaching of Geography, May 27 - 28, 1958. (Great Britain: International Geographic Union, 1970).

[21] Brown, pp. 19 - 28.

> visualizing of relief from contour lines, the use of grid reference systems, and the teaching of the location of individual buildings can be introduced; more difficult problems such as understanding of scale, require the pupil to be eleven plus. While students need to be fourteen or older to interpret physical features and to discuss settlement problems.

Dale's investigation concerned children's reactions to maps and photographs.[22] Children in the 7 - 11 year age range were examined. The test materials were a topographic map and a vertical aerial photograph with approximately the same scale and representing the same scene. Dale's study revealed that the ability to read maps is related to spatial intelligence although patterns of social behavior are a key factor.

He found that the main difficulty for children reading a map or aerial photograph was forming a mental picture which could be keyed into the relevant map form. However, the more familiar the child was with the area, the more he tended to prefer a map, but when he was uncertain of the area, the photograph gave him greater confidence. Dale observed that children were able to learn the elementary language of both the map and photograph with equal ease, although fewer mistakes were made initially on the photograph. Dale's general conclusion was that the children tended to prefer the vertical aerial photograph.

[22] P.F. Dale, "Children's Reactions to Maps and Aerial Photographs," Area, 3 - 4 (1971 - 72), pp. 170 - 175.

11. The Use of Road Maps in Elementary Grades

The literature related to road maps as a teaching aid in the elementary grades was minimal. Some educators, as noted below, have recognized the merits of road maps for map studies in geographic learning and these sources of literature were examined.

Most recent road maps in North America are cartographically created from ground observation data, aerial photographs, and Landsat imagery.[23] The road map has an established scale, representations of cultural, hydrological, and physical features, and compass directions. It contains basic characteristics similar to conventional topographic maps such as size, shape, pattern, site, color, and association of features. These elements can be used to build needed map interpretation skills, as well as provide the interpreter with accurate and current information if the road map is up-to-date.

Both Sabaroff and Hanna state the uses of the city road map for recognizing, locating, and identifying familiar features as well as for orientation and delineation of specific items.[24] They

[23] Don Picard, "Getting Your Here from There," in Alberta Motorist supplement in Alberta Magazine, Vol.3 No.4 (July/August, 1982), p. 8.

[24] See, Sabaroff, 1958, p. 413; and Hanna, P. et al., pp. 18 - 44, 184.

conclude that these road maps have relevance for developing map reading and map interpretation skills with young children.

Sabaroff points out that skills and concepts learned from various maps, including road maps, by grade two children, would have much broader use for interpreting landscapes later on that are not available for first-hand observation.[25]

Conversely, Kohn points out that by the time youngsters have reached the fourth grade they should be ready to use road maps, which these too children must learn to orient before using.[26] While the age differences for using road maps are evident between Sabaroff and Kohn, the recognition for the use of road maps in the elementary school is indicated.

Wake and Hull suggest the use of non-remote sensing data which includes the road map. They point out that such collateral data could enhance both the demonstration of utility of remote sensing data and the effects of field work.[27] They affirm that "the symbolism and portrayal of physical and cultural features on maps are an excellent supplement to imagery for the novice interpreter learning to work with remotely sensed imagery of the objects and

[25] Sabaroff, p. 414.

[26] Kohn, p. 149.

[27] Wake and Hull, p. 39.

phenomena of the natural environment and its uses."[28] Wake and Hull do not report on the ability of children using the road map.

While mapping exercises using the road map with junior and senior students have been reported, there are no studies to date dealing with the ability of young children to use road maps. Ferguson's study with junior high school students using the road map makes mention of adapting road map skills for use with elementary children.[29]

In the Kirman studies using Landsat C1 imagery, road maps were successfully used by the children.[30] However, no reports on the children's ability to use road maps were indicated.

111. The Use Of Aerial Photographs in the Elementary Grades

Photographs may be classified into three broad categories depending on the location or site of the lens producing the image namely: terrestrial, aerial, and satellite photographs.[31] They are all iconic representations of the Earth's surface features.

[28] Wake and Hull, p. 39.

[29] J. Ferguson, "Using Road Maps in the Junior High School," Journal of Geography, 75 (Dec., 1976), pp. 570 - 574. See also, J. Ehemann, "The Highway Map as a Social Studies Resource," Clearinghouse, 51 (Dec., 1977), pp. 165 - 166; and Keith Donald, "Ontario Road Map Test," The Monograph, No. 3 (1978), pp. 17 - 21.

[30] Kirman, p. 58; J. M. Kirman, "An Exploratory Study of Landsat Multispectral Use by Grade Six Children," A Report to the Alberta Advisory Committee for Educational Studies, (Mar. 23, 1982), p. 3.

[31] Donald O. Bushman and Richard G. Silvernail, "Terrestrial, Aerial, and Satellite Photograps," Journal of Geography, 69 (May, 1970), pp. 285 - 286.

Terrestrial or 'ground-observed' photographs were first adapted for classroom use. Since they gave an indication as to the ability of elementary children using iconic representations, the findings of studies done by Long, and Bayliss and Renwick bearing directly on this study are briefly stated.

Long's first study demonstrated the ability of 9 - 10 year old children using photographs for obtaining geographic information.[32] Her findings indicated that: the children were able to interpret the photographs, but they must be guided to do so; photographs should show much detail; factors such as the child's interest, emotion, and imagination facilitate interpretation; and the element of shape recognition is stronger than size recognition.

Bayliss and Renwick tested children 7 - 11 years of age using black and white terrestrial photographs of the children's home district.[33] Their findings gave an indication of how primary children see photographs from non-directed and directed observation. In addition, the findings of Bayliss and Renwick compared the efficiency of field experiences, photograph studies, and blackboard instruction.

[32] Molly Long, "Children's Reactions to Geographic Pictures," Geography 38 (April, 1953), pp. 100 - 107.

[33] For Bayliss and Renwick, See, D.G. Bayliss and T.M. Renwick, "Photograph Study in a Junior High School," in J. Bale, N. Graves, and R. Walford, Perspectives in Geographic Education (Birkenhead: Oliver and Boyd, 1976), pp. 119 - 129.

Except for the identification of more cultural than physical features as found by Long in her second study,[34] the results of Bayliss and Renwick appear consistent with Long's findings in both her studies. They concluded that:[35]

> Photographs are a valuable aid in the junior school, but children must be guided in their use; simple concepts could be introduced and photographs should concern a familiar site to the child; and, the use of photographs indoors is not necessarily followed by better perception outdoors.

Aerial photographs give a bird's-eye view of large areas, enabling us to see Earth's surface features in their spatial context.[36] They represent iconically, a mass of current and detailed information which can be used to learn about the Earth.

Investigation into a new and different approach for young children to learn geographic concepts led to the use of aerial photographs.[37] Blaut theorized that "environmental mapping" is a natural skill with children, commencing very early in human development as demonstrated in their toy-play on the ground.[38]

[34] Molly Long, "Research in Picture Study, The Reaction of Grammar Pupils to Geographical Pictures, Geography, 46 (Nov., 1961), p. 336.

[35] Bayliss and Renwick, p. 129.

[36] Lillesand and Kiefer, p. 35.

[37] Blaut, Report No. 1, pp. 14 - 18.

[38] Blaut, pp. 14 - 18.

He thus hypothesized that if mapping is a natural skill with children, learned as a necessary adjunct to the environmental behavior displayed in their toy-play, then an iconic model such as an aerial photograph, which is a reduction of the real world, could be used quite easily by children.[39]

Blaut and Stea conducted a series of investigations to observe young children's mapping behavior and the ability of young children to use aerial photographs. They examined the ability of children ranging from 3 - 5 years of age using toys,[40] and children 5 - 12 years of age using black and white vertical aerial photographs, to determine their mapping abilities.[41]

These investigations, of which a few are cross-cultural, have direct implications to the present study. They show a natural mapping ability of children, their ability to interpret vertical aerial photographs, and the practicality of teaching geographic theory with the aid of aerial photographs to children at or before the age of nine.[42]

[39] Blaut, pp. 19 - 20.

[40] J.M. Blaut and David Stea, "Place Learning," Place Perception Research Reports, No. 4. Clark University (Dec., 1969), pp. 22 - 24; and in, Blaut and Stea, "Mapping at the Age of Three," Journal of Geography, 73, No. 7 (Oct., 1974), pp. 5 - 9.

[41] Blaut, pp. 14 - 22.

[42] Blaut and Stea, in Bale, Graves and Walford, pp. 87 - 98.

Blaut and Stea conducted four studies as follows:

Study I tested their hypothesis that a child of school entering age can interpret black and white vertical aerial photographs and recognize the image as a reduced, rotated view of the Earth's surface. The findings indicated that the population tested was able to perform iconic map reading operations which are implicit in photo-interpretations, thus demonstrating the ability to interpret black and white vertical aerial photographs.[43]

Study II tested whether a child of school entering age can make an environmental map using a black and white vertical aerial photograph. The findings of the investigation found this to be so.[44]

Study III involved the extent to which Puerto Rican children 5 - 12 years of age can interpret black and white vertical aerial photographs of a familiar site. The results indicated that the subjects were able to identify the aerial photograph and the cultural and physical features within the photograph.[45]

Study IV reported on the investigation of toy-play mapping

[43] Blaut, Report No. 1, p. 26; and Blaut and Stea, Report No. 4, p. 15.

[44] Blaut, Report No. 1, pp. 27 - 28, and Blaut and Stea, Report No. 4, pp. 15 - 16.

[45] Blaut and Stea, Report No. 4, pp. 16 - 22.

with youngsters three to five years of age.[46] Blaut and Stea hypothesized that children in this age group in free toy-play will assemble toys into a map-like model of a macro-environmental or geographic region which requires a cognitive map for comprehension and navigation. The authors theorized that the operations of reduction in scale and rotation of perspective, which they assume to be involved in the successful interpretation of aerial photographs, are learned in part through play with "environmental toys;"[47] and that such a toy-model would be both a cognitive or 'mental' map and a simple physical map in its own right.[48]

The children were given three exercises to test the hypothesis. It was reported that some children created patterns of environmental organization which were "models of communities," while others grouped their toys according to form and color. The children's verbal responses indicated various names for communities and cultural features.[49]

Blaut and Stea concluded that by the age of three, the

[46] Blaut and Stea, Report No. 4, pp. 22 - 24, and Blaut and Stea, (Oct., 1974), pp. 5 - 9.

[47] Blaut and Stea, Report No. 4, p. 23

[48] Blaut and Stea, (Oct., 1974), pp. 5 - 6.

[49] Blaut and Stea, Report No. 4, p. 23.

children in the sample were able to represent a cognitive map in the form of a physical map even though the three-year-olds were unable to verbalize as well as the four and five-year-old ones. The authors state that the cognitive mapping is a form of spatial cognition and the taproot of ordinary mapping, and that the child is already a mapmaker at the age of three.[50]

The researchers suggested further studies for refinements in testing procedures and statistical analysis.[51]

The general results of the studies indicate that children have a natural mapping ability, and by school entering age can read and interpret black and white vertical aerial photographs as well as make a map using an aerial photograph.

Hart's experiment concerned the effect of flying as a perceptual or motivational supplement to the use of black and white vertical aerial photographs.[52]

Hart wished to examine the ability of grade three children using black and white vertical aerial photographs for the

[50] Blaut and Stea, (Oct., 1974), pp. 7 - 9.

[51] Blaut and Stea, Report No. 4, p. 24.

[52] Hart, p. 14.

interpretation of major categories of macro-scale features in an urban environment, the recognition of unfamiliar environment presented at various scales, and abstract major land uses and "place wholes."[53] Hart used eight black and white aerials comprised of large and small scales representing urban and rural sites of the same region, and outline maps of the same area. His sample consisted of an experimental group, Group A, which was the flying group, and Group B, the control group. Both groups received the same instructions, the same aerial photographs and the same tests.[54]

Hart reported that:[55]

> Grade three children can use aerial photographs. The large scale aerials were easier to interpret than the small scale and the use of these maps is not related to the children's reading ability.

Hart stated that the understanding of cardinal directions is not necessary for orientation. Cardinal directions were not given to the children during the course of instruction; however, the children did orient their photograph to the teacher's projected

[53] The terms "place wholes" or "wholes" have been used by some researchers namely: Long (1953, p. 102), Bayliss and Renwick, (p. 123), Blaut (Report No. 1, p. 8) and Blaut and Stea (Report No. 4, pp. 7 - 13), and in Hart, p. 14. It is explained by both Blaut and Stea to mean "the perception of place or environment as a whole."

[54] Hart, p. 17.

[55] Hart, p. 36.

copy. Hart specified that the flying group showed greater improvement with only one of the photograph tests hence, any improvement in learning that might come from a supplementary flying experience would be largely motivational.[56]

Other findings concerned the element of shape for the recognition of cultural features such as the children's own homes; the use of small scale photos for identifying macro-environmental features; the difficulty of discriminating some of the photos' hydrological features due to the spectral reflectance pattern of water in the visible range of the spectrum; and the type of questions which should generate answers from the aerial photographs.[57]

The children were re-tested after six months, with no additional flying or aerial photograph instruction for their retention of ability to use three of the vertical aerial photographs. The flying group's superior performance earlier was not repeated.

Muir's study examined the ability of grade one children to use black and white aerial photographs for learning map skills.[58]

[56] Hart, pp. 47 and 64 - 65.

[57] Hart, pp. 48 - 65.

[58] Merrie Ellen Muir, "The Use of Aerial Photographs as an Aid in Teaching Map Skills in the First Grade," Unpublished Master's Thesis, Clark University, 1970.

Muir used a variety of black and white vertical aerial photographs of familiar and distant sites in the same region. The subjects were asked to identify features and map the environmental phenomena shown to them, and instructed to produce maps with legends, map signs, and color for their representations.

Muir found that these grade one children were able to accurately identify most symbols on the aerial photographs even when various low altitude scales were used.[59] There was no apparent relationship between I.Q. score and test-difference score, and very little or no difference between reading level and test-difference score. Muir concluded that first graders can acquire the basic map skills from a combined use of black and white vertical aerial photographs and a topographic map, and that first grade children are able to learn geographic concepts such as resource development, cultural innovation, location theory, and central place.

Kingston in her study examined the ability of children in grades one, two, and three to read and interpret black and white vertical aerial photographs of three different scales.[60]

59 Muir, pp. 58 - 78.

60 B.E. Kingston, "Reading and Interpreting Vertical Aerial Photographs in the Primary Grades," Unpublished Master's Thesis, University of Calgary, (April, 1969), pp. 30 - 35.

Kingston found that:[61]

> Scale did not present a problem; with direction children would identify twice as much using vertical aerial photographs than without direction; young children performed better at the lowest level of cognition which is identification; there was no significant differences between the proportion of cultural and physical features identified within each grade; children were interested in high or medium photographs that showed a variety of detail; and, children showed interest and appreciation of pictures. Kingston also found that interpreting vertical aerial photographs present some difficulty without any previous teaching.

Dueck conducted a study similar to Kingston.[62] Using the same scale of black and white vertical aerial photographs but with children at the grades four, five, and six levels, Dueck found that these children were able to read and interpret vertical aerial photographs. Except for her findings that the average performance of grade five children was better than that of the four and six children, Dueck's general findings appear consistent and supportive to Kingston's.[63]

It would appear that for the depiction and interpretability of certain aspects of the Earth's surface features, such as vegetation, water, soils and concrete, color infrared vertical aerials may be considered superior to natural color or black and

[61] Kingston, pp. 63 - 85.

[62] Dueck, p.2.

[63] Dueck, pp. 52 - 90.

white photographs, and can be used with other forms of imagery bearing similar color coding arrangements.[64] Since there are no studies to date that indicate the use of color infrared vertical aerial photographs with children, literature related to the use of color photographs and color aerials by children were examined.

A cross-cultural investigation in the use of color photographs was conducted by Jahoda et al.[65] Using Polaroid color prints of known objects such as a calabash, orange, twig, stone, etc., the researchers attempted to determine whether three-year-olds could identify the objects on the colored photographs after being trained to identify the same objects. These children from Ghana and Rhodesia had never handled photographs before.

The findings of this research indicated that three-year-old children can recognize features on a colored photograph. It was stated that color provided an additional cue for recognition and may have made the task easier.

The researchers maintain that visual experiences of objects in the real world are sufficient to lay the foundation for the ability of picture recognition.

64 Reeves et al. pp. 931 - 933.

65 G. Jahoda, J.B. Deregowski, E. Ampere, and N. Williams, "Pictorial Recognition as an Unlearned Ability," in G. Butterworth, <u>The Child's Representation of the World</u>, (New York: Plenum Press, 1977), pp. 203 - 213.

The use of color aerial photographs to teach map reading to elementary children has been reported by Riffel.[66] He felt that color aerial photographs or stereograms might bridge the gap between reality and map reading. He hypothesized that since black and white stereo pairs were effective with older children in studying geologic and geographic principles, color stereo pairs might work well with elementary students. Riffel did not test this hypothesis and suggests the need for further studies.

Research in the use of three-dimensional aerial photographs or anaglyphs with children provides a clue as to whether children can identify features from such an aerial view and in color. In anaglyphic interpretation, a stereoscopic image is mentally created by superimposing two aerial images in complimentary colors, usually red and green, to be viewed through filter spectacles of the corresponding colors.[67]

A preliminary investigation of children's recognition of rural features from anaglyphic representations of vertical aerial photo-

[66] Paul A. Riffel, "A New Approach to Map Reading," Journal of Geography, 68 (Dec., 1969), pp. 554 - 556.

[67] Ronald J.B. Carswell, Gary, J.B. DeLeeuw, and John F. Early, "Children's Recognition of Rural Features from Anaglyphic Representations of Vertical Aerial Photographs," Unpublished Paper presented at the Western Meeting of the Canadian Association of Geographers, Kelowna, British Columbia, March, 1981.

graphs was reported by Carswell, DeLeeuw and Early.[68] These researchers, using both the directed and non-directed methods of observation, and an anaglyph of an upland farming region in West Germany, with grades four, five, and six students, found that the children were able to recognize relief.

They observed that a higher proportion of errors were made by grade four children than by those in grades five and six in identifying certain features. Perhaps if a known site were used, more correct identification of features might have been indicated.

Early extended this study by using both vertical aerial photographs and anaglyph representation of the West German scene with students from grades two, five, and eight.[69] Restricting the interpretation to the identification of physical features, Early found that grades two and five children were able to recognize relief on the anaglyph better than on the aerial photograph; grade eight students were able to use the vertical aerial just as well as the anaglyph and they were able to identify more physical features representing a more vertical perspective than cultural features such as buildings or roads on the anaglyph than on the aerial photograph.

The relevancy of these studies to the present study is the children's ability to obtain information from an aerial perspective

[68] Carswell, DeLeeuw, and Early, n. pag.

[69] Carswell, DeLeeuw, and Early, n. pag.

and using color images. The authors did not indicate whether the color factor of anaglyph representations was a clue in the identification of features. However the success of the children in interpreting anaglyphs may make this seem to be so.

1V. The Use of Landsat C1 Imagery in the Elementary Grades

Landsat imagery is satellite-acquired remote sensing data of the Earth's surface. Travelling around Earth in a near-polar orbit, Landsat transmits detailed images of the terrain it passes over. Reflected light energy from Earth directly below the satellite is collected and measured by its Multispectral Scanner System (MSS). Landsat's MSS detects four wavelength bands in the electromagnetic spectrum (EMR) to record this light energy. The bands are two in the visible spectrum at 0.5 to 0.6 μ m, and 0.6 to 0.7 μ m, and two in the relected IR at 0.7 to 0.8 μ m and 0.8 to 1.1 μ m. This data is then transmitted to Earth where it is received and converted into Landsat MSS images from which C1 images are generated.

Each Landsat MSS scene is "framed" from the continuous MSS data swath so that it covers approximately a 185 km by 185 km area with 10% endlap between successive scenes. Each Landsat MSS image covers an area of 34 225 sq. km. with a scale of 1:1 000 000 on a 18.5 cm by 18.5 cm image.[70]

[70] Given the vast and detailed information of Landsat's remote sensing capabilities and application, I have attempted to

An introduction to Landsat imagery by Nixon and McCormack discussed Landsat's various applications including its use as a tool in the classroom.[71] The authors explained that Landsat images can provide information to aid in solving environmental and ecological problems, and that these images can be used in the classroom for learning geographic concepts.

According to Kirman, "Landsat is the latest technology in the production of maps."[72] Landsat images are similar to terrestrial and aerial photographs. The latter two represent "the closest approximation of places, people, or things among the various categories of still pictures, and make accessible for examination

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describe briefly the acquisition of Landsat's C1 images which pertains to this study. For additional detail, see, Dorothy Harper, Eye in the Sky: An Introduction to Remote Sensing (Montreal: Multiscience Publications, 1976); T.M. Lillesand and R.W. Kiefer, Remote Sensing and Image Interpretation (New York: John Wiley and Sons, 1979), pp. 442 - 443 and 528 - 583; J. Lintz, Jr. and David Simonett, Remote Sensing of Environment (Reading: Addison-Wesley, 1976), pp. 85 - 105; Dick Yost, "New Eye in Space: Lnadsat-4," Popular Science, (Dec., 1982), pp. 60 - 63; NASA, Spinoff 1981, (Washington, D.C.; GPO 1981), pp. 14 - 21 and 118 - 119; Interdepartmental Committee on Space and Ministry of State for Science and Technology, Canada in Space, (Ottawa: Government of Canada, 1982), pp. 1 - 3.

71 William D. Nixon and Richard E. McCormack, "Landsat - A Tool for Your Classroom," Social Education, 40 (Nov. - Dec., 1977) pp. 602 - 622.

72 Joseph M. Kirman, Primer for Satellite Maps, (Edmonton: Puckrin's Production House, 1978), p. 3.

aspects of natural and human phenomena not readily available to the human eye."[73]

Landsat images are currently being used in: cartography, geography, geology, hydrology, marine studies, agriculture, forestry, and land management, with some applications to mapping changes in land use, assessing hydrologic problems, studying erosion and change along coastlines and major streams, determining conditions of rangelands and forest areas, mapping of geologic structures that relate to mineral and fuel deposits, and monitoring the environment.[74]

For geographic applications, Landsat data provide information for land use and land cover, repetitive coverage for analyzing urban growth, crops, transportation linkages, and environmental conditions; and for assessing effects of disasters and functional changes involving natural and man-made activities and resources.[75]

Consequently, Landsat images can be used in the social studies program in the classroom since they are perhaps more informative

[73] George H. McHune and Neville Pearson, "Interpreting Material Presented in Graphic Form," Thirty-third Yearbook, ed. Helen Carpenter (Washington: National Council for Social Studies (N.C.S.S.) 1963), pp. 202 - 229.

[74] U.S. Dept. of the Interior/Geological Survey, Studying Earth from Space, (Washington, D.C.: Government Printing Office, (GPO), 1981), p. 7.

[75] U.S. Dept. of the Interior, Studying Earth from Space, pp. 12 - 14.

and accurate than any hand-drawn map based on previous cartographic technology.[76] They can improve geographic teaching in three ways.[77] First, they provide macro scaled environmental features for multiple uses. Secondly, they represent a variety of phenomena such as natural features and patterns of human activity, and thirdly, their "false-color" rendition compels a more careful look at the environment in terms of light, color, and reality. For example, grass is by nature not always green, neither is water always blue. Studying Landsat C1 images provides an understanding of such differentiation.

The earliest investigations of using Landsat maps with elementary school children were initiated by Kirman. In the first investigation, Kirman wished to examine the ability of grades three, four, and five children to use Landsat C1 images.[78] Since this project was of an exploratory nature, the teaching method was left up to the teachers. The teachers selected two Landsat C1 images of the Edmonton region rather than the MSS black and white

[76] J.M. Kirman, "The Use of Infrared False Color Satellite Images by Grades 3,4, and 5 Pupils and Teachers," The Alberta Journal of Educational Research, 23, No. 1 (March, 1977), p. 53.

[77] F.M. Henderson and T.J. Rickard, "Space Photographs as a Geographic Teaching Aid," The Journal of Geography, 71 (May, 1972), pp. 307 - 313. The authors refer to the general use of color space photography in geographic education and similarly suggest three ways space images can be used. Since Landsat C1 images are space-obtained data, they could be included in their category of space photographs.

[78] Kirman, March, 1977, pp. 52 - 64.

images. It was reported by Kirman that the teachers felt the attractiveness of Landsat's false color and its contrast between Earth surface features could prove more effective with the children.

Kirman tentatively concluded that grades three, four, and five children seemed to be able to work with Landsat C1 images and obtain data from them. Kirman suggested that further investigation was needed to determine the extent to which children can apply Landsat-derived data to solve geographic problems.

Kirman conducted another investigation, this time with Landsat MSS band 5 images.[79] He wished to determine the ability of grades three, four, and five children to use these black and white images. They consisted of a vegetation and a snow cover image of the Edmonton region and an image of the lower half of the Vancouver-Victoria area. Regional road maps complemented the study. Three teachers were involved in this project, in which a 'discovery' teaching procedure was used.

Kirman's findings indicated a small measure of capability in interpreting the Landsat Band 5 images, which prompted a follow-up investigation.

[79] J.M. Kirman, "The Use of Band 5 Black and White Landsat Satellite Images in the Grades 3, 4, and 5 Levels," Journal of Geography, 80, No. 6 (Nov., 1981), pp. 224 - 228.

In this extended project emerging from the previous exploratory study, Kirman examined the ability of only grade three children using the same materials.[80] There were 14 boys and 15 girls. The children had no prior knowledge of Landsat C1 or MSS imagery. The teacher was requested by the researcher to use specific objectives and a direct method of teaching.

Kirman found that the grade three children were able to interpret Landsat's MSS band 5 images. The finding appears to reflect the significance of instruction using specific objectives and the direct teaching method in using Landsat imagery.

Another exploratory study to determine the use of Landsat MSS images by grade six children was undertaken by Kirman.[81] In the previous study, Kirman used only band 5 with grade three children. In this project, Kirman used bands 4, 5, 6, and 7 of an Edmonton region. He wished to examine the ability of these children to undertake multispectral interpretation.

The total instructional time was 15 hours which involved following specific learning objectives. Alberta road maps were

[80] J.M. Kirman "Band 5 Black and White Landsat Images: A Definitive Finding for Grade 3 and Upper Elementary Levels," A Second Interim Report to the Alberta Advisory Committee for Educational Studies, March, 1981, in Press - Social Education.

[81] J.M. Kirman, "An Exploratory Study of Landsat Multispectral Use by Grade Six Children," A Report to the Alberta Advisory Committee for Educational Studies, March, 1982.

used to supplement ground information as well as for orientation.

Kirman found that the children examined demonstrated some ability to interpret certain details in Landsat MSS bands 4, 5, 6, and 7 for multispectral examination. The researcher noted that these children were rated as lower than average; therefore, average and above-average groups may be able to perform at a higher level. The findings of this study also indicate the amount of learning was dependent upon the remote sensing background experience of the teacher.

The findings of this study, while not definitive, seem to suggest that grade six students may be able to use Landsat MSS images for learning geographic concepts of a familiar region.

Landsat C1 images were used in another project conducted by Kirman and Goldberg.[82] This study involved the use of telephone conferencing as a means of supervising a large number of student teachers learning about C1 images. Landsat C1 images were used to measure the achievement of the student teachers' pupils from grades four, five, and six.

The effectiveness of telephone conferencing appeared uncertain. However, a secondary finding indicated that the pupils

82 J.M. Kirman and J. Goldberg, "Student Teacher Telephone Conferencing with Satellite Maps as a Monitoring Device," The Alberta Journal of Educational Research, 25 (Dec., 1979), pp. 275 - 283.

taught by the telephone supervised group did just as well as the control group's pupils in learning about Landsat C1 images.

A follow-up of the above study was conducted by the researchers.[83] Landsat C1 images were used again as a monitoring device. This project was to determine the use of one-way television instruction with simultaneous group conferencing.

Thirty teachers and 718 elementary students in grades four, five and six participated in the project. The experimental group of teachers received their five-hour Landsat instruction via one-way cable color television at three different centers. The control group of teachers received their five-hour Landsat instruction face to face at one center. Both groups received the same instruction by the same instructor and received identical materials. The Landsat unit was taught to the children by both groups for three weeks. The children had not used Landsat images before.

The findings indicated that five hours of instruction is sufficient to provide elementary teachers with training to use a Landsat C1 image in the classroom. The findings confirm that elementary level pupils are capable of working with Landsat C1 images. The results showed that the boys did slightly better than

[83] Joseph M. Kirman and Jack Goldberg, "A Landsat Color 1 Inservice Training Program for Elementary School Teachers and the Mass Testing of Their 718 Pupils," A Supplementary Report to the Innovative Projects Fund, Alberta Dept. of Advanced Education and Manpower, Program Services Division, Sept., 1980. In press - Canadian Journal of Remote Sensing.

the girls, and the children seemed to use the element of color over shape in their interpretation of physical features in Landsat C1. Some confusion is reflected in their recognition of snow and cloud cover. Since those features as well as cleared farmland appear white-toned on Landsat C1 images, the children perceived most white-toned surface features on the images as snow.

The use of Landsat C1 imagery was deemed significant by the University of Alberta's Faculty of Education and a probative teacher training course was offered.[84]

A project in the use of Landsat C1 and other remote sensing data was conducted by Smith.[85] He examined the ability of academically-gifted grade six students to use these materials for the purpose of motivation, acquiring and structuring knowledge related to remote sensing, and the application of remote sensing data for learning social studies and science concepts, and technological and social issues.

Smith found that these academically-gifted grade six students were capable of acquiring and structuring knowledge related to remote sensing; that the remote sensing unit appeared to influence,

[84] Joseph M. Kirman, "A Probative Teacher Training Course in Landsat Imagery at the University of Alberta's Faculty of Education," Remote Sensing Quarterly, 2 (July, 1980) pp. 25 - 31.

[85] Grant Smith, "Remote Sensing with the Academically Gifted," Unpublished Master's Thesis, University of Alberta, 1982, p. vi.

in a positive direction, the development of student understanding regarding science, technology, and society; and that the application of remote sensing data including Landsat C1 can be used as an interfacing medium to teach science and social studies concepts.[86]

A more recent project using Landsat C1 imagery was done by Burke.[87] Using a computer-assisted (CAI) program as a teaching aid, Burke examined a sample of grade six children of average ability to interpret Landsat C1 imagery for learning certain cultural, geographic, and hydrologic targets.

The results of Burke's study indicated that Landsat C1 imagery could be used by the grade six subjects.[88] Burke also observed that the computer-assisted Landsat program developed by him, may have enhanced the interpretation of Landsat C1 imagery by these children.

V. Summary

Maps have a function in the classroom for learning geographic and environmental concepts and skills in the social studies program. Originally, maps used in the classroom were the conventional topographic maps, atlases, globes, and wall maps. Research

[86] Smith, p. vi.

[87] Brian Burke, "A Landsat Color I C.A.I. Program for Grade 6 Students," Unpublished Master's Thesis, University of Alberta, 1983 p. 3.

[88] Burke, p. 40.

has shown that the abstraction and symbolization of conventional topographic maps present certain difficulties for young map interpreters, and also that road maps can be used for learning certain map skills. However, road maps and other topographic maps do not represent the topography of the terrain as do aerial and satellite imagery.

Technologically-acquired maps such as aerial and satellite imagery provide accurate, timely, reliable, and pictorial environmental information which can be used to study about the Earth and its resources.

Evidence from the research reveals that children possess a natural mapping ability which allows them to interpret iconic representations more readily than the conventional topographic maps.

Children in grade one can interpret black and white vertical aerials, grade two students can use color stereo pairs, and children in grade three can interpret Landsat C1 images and obtain geographic information from them. Evidence also indicates that a variety of maps of different scales, particularly of the same site, may be used with children, and a direct method of observation can better facilitate the interpretability of iconic maps. There is evidence showing the need for children to orient the map being used, the importance of image-related questions, and the need for

background knowledge by the teacher for children's successful interpretation of aerial and satellite imagery.

Since elementary children can interpret black and white vertical aerials, color photographs, color stereo pairs, and Landsat C1 imagery, they should be able to interpret color infrared vertical aerial photographs. Correspondingly, if they can interpret color infrared vertical aerial photographs, they should be able to use them in conjunction with Landsat C1 imagery and a road map, each representing the same region. These are what were examined in this study.

CHAPTER III

RESEARCH PROCEDURES

This chapter describes the selection of the sample, the test battery administered, and outlines the procedure employed in scoring the test battery.

A. THE SAMPLE

The sample was selected from one elementary school of the Edmonton Public School System. The subjects for the investigation consisted of six students of varying abilities drawn from the grade four class with the help of the teacher.

The teacher was interviewed. She had five years' experience with teaching grade four children and agreed to participate. The nature of the study was discussed, and the teacher stated that no map studies had yet been undertaken in that school year. She explained that the four cardinal directions had been referred to, but no classroom activites with road maps, black and white or CIR vertical aerials, or Landsat images had been done so far. The children's IQ. and reading scores were requested by the investigator but were confidential information and could not be released.

In earlier exploratory research by Kirman, the methodology of a selected class sampling in the categories of above average, average, and below average, as determined by the teacher for an oral achievement examination, appeared to be a usable procedure for exploring children's abilities to use iconic representation such as Landsat imagery.[1] This method was employed in this study.

The teacher was requested to list the grade four children by numbers in the three categories, namely: above average, average, and below average. Two students in each of these categories were randomly selected by the researcher. All students in each category had an equal chance of being selected. A total of four males and two females at the grade four level were selected (see, Table 1).

TABLE 1

DESIGN OF THE SAMPLE

	Males	Females	Total
Above Average	1	1	2
Average	2	0	2
Below Average	1	1	2
Total	4	2	6
	N=6		

A letter (Appendix A) describing the purpose of the study was sent to the parents of each child in the sample. Parents consented

[1] See, Kirman, 1977, p. 57; Kirman, March 1982, p. 4 - 5.

to their children's participation in the investigation.

A request was made by the researcher for the children's visual acuity. This information could not be released because of its confidential nature. Consequently, on the basis of the teacher's experience, and the length of time with the children, the teacher was asked about each subject's visual acuity. None had any problems that she could note. Two children wore glasses (see, Appendix F, Table 8).

Each subject was tested for color-blindness. It was found that one subject was partially color-blind. The administration and findings of the color-blind test will be found in Appendix C.

The sample of children were instructed in the Remote Sensing Teaching Unit (RSTU) which dealt with the use of a road map, color infrared vertical aerial photographs, and a Landsat C1 image, each of the Edmonton site. The RSTU was taught for nineteen and one half hours prior to the administration of the Remote Sensing Oral Achievement Test Battery. The RSTU will be found in Appendix D. During the RSTU, the children were taught what each map was; how aerial and satellite images are obtained; to interpret features; to map certain targets; and to use the maps together.

Every effort had been made by the researcher and the Alberta Remote Sensing Center to obtain CIR vertical aerials and Landsat C1 imagery of the highest quality and which would not restrict the children's learning potential. The materials were selected to

harmonize the multistage remote sensing approach and were the best that were available at that time. Only one image, the small scale CIRVAP used in the testing situation (see, Appendix G, Plate 2) had a dark tone around its edges. Since another vertical was not available to correspond with the Calgary test site as in the road map and the Landsat C1 image, it had to be used. The dark tone did not affect its value for test purposes.

B. THE TEST INSTRUMENT

The measuring instrument used was the Remote Sensing Oral Achievement Test Battery, (RSOATB) prepared by the researcher. This battery of five tests was based on a road map, two color infrared vertical aerial photographs, and a Landsat C1 image each of the Calgary site (see, Appendix G, Plates 1-4). A copy of each of the five tests is found in Appendix F.

The Remote Sensing Oral Achievment Test Battery (RSOATB)

For the purpose of this study, it was necessary for the researcher to construct a battery of tests that would measure the ability of grade four children to use color infrared aerial photographs in conjunction with satellite imagery and a road map. A similar instrument was not available insofar as could be determined.

The RSOATB requires each subject to be tested individually. This method of testing appears practical when using various map materials with a small sample. In Dueck's study on the use of

aerial photographs by grade four, five, and six children, a constructed testing instrument (Aerial Photograph Reading and Interpretation Instrument) (APRII) was used with sixty children.[2] It was administered in a clinical setting on a one-to-one basis. The Kirman studies on Landsat imagery also demonstrated the viability of the oral practical examination with small numbers of children in an individual setting.[3]

Content validity of the RSOATB was established by consultation with the following authorities:

1. Dr. J. Kirman, Professor, Department of Elementary Education, and Director of Project Omega for Remote Sensing and Aerospace Education, University of Alberta.

2. Ian Sutherland, Remote Sensing Technician, Alberta Remote Sensing Center, Edmonton, Alberta.

Reliability of the RSOATB was predicated on its being "a skill performance before a qualified examiner on a one-to-one basis. Skill performance demonstrates a learned behavior that may reasonably be expected to be repeated with the same or similar material."[4] Dueck's instrument (APRII) was also conducted using skill performance.[5]

[2] Dueck, pp. 35-41

[3] See, Kirman, 1977, pp. 57-69; Kirman, 1981, pp. 225-227; Kirman, 1982, pp. 4 - 5.

[4] Kirman, 1982, p. 4.

[5] Dueck, p. 40.

The RSOATB was comprised of the following tests:

1. The Road Map Test.
2. Map 1 Test.
3. Map 2 Test.
4. Landsat C1 Test.

A description of each test in this instrument is as follows:

1. The Road Map Test

The Road Map Test (Appendix F, p. 179) is designed to measure each subject's understanding of the type of map, the subject's sense of orientation with a road map, and the subject's ability to detect surface features.

The test consists of eleven items. These items are arranged to elicit answers reflecting the subject's ability to recognize a road map, the ability to recognize cardinal directions, and the interpretation of cultural, physical, and hydrological features. The Road Map Test is based on a 1980/81 official road map of Alberta on which the map of the city of Calgary was used. A profile for this road map is given in Appendix B (Table 9). The maps measured 25 cm x 30 cm and were laminated for easier use.

The Alberta Road Map is organized from the following data:[6]

a) Registered plans and surveys.
b) Most recent aerial photographs.
c) City records for proper names of streets and features.

Thus, the accuracy of the signs and symbols and topographic features of the road map seem to provide satisfactory collateral data for use with remote sensing imagery, as well as sufficient supplemental surface information for the children to use with the aerial and Landsat maps.

2. <u>Map 1 Test</u> [High Altitude, Small Scale, Color Infrared Vertical Aerial (CIRVAP)]

Map 1 Test (Appendix F, pp. 180-83) is based on Map 1, a small scale, high altitude, CIRVAP of the city of Calgary. The flying height for Map 1 was 11,286.3 m (37,621 feet) with a photographic scale of 1:118,000. A complete profile for Map 1 is given in Appendix B (Table 9).

[6] Telephone Interview with Ed Kennedy, Mapping Director, Alberta Bureau of Surveying and Mapping, May 17, 1982.

Map 1 Test is comprised of Parts A and B. Part A sought to determine the children's understanding of how vertical aerial photographs were taken and their ability to detect and identify land cover features on a small scale CIRVAP. Part A was made up of five items which required nine responses using Map 1. Part B was designed to examine the extent to which grade four children can apply prior knowledge from the road map to a small scale, high altitude, CIRVAP, and to determine their ability to identify particular land cover features on it.

The items were arranged for detection and then identification of features. Detection required each subject to examine the map and tell what could be found. For identification the subject was asked to identify specific items. Map 1 was placed in an acetate-cardboard envelope (30 cm x 20 cm). Each child's responses were marked on his individual acetate envelope with indelible felt markers.

3. Map 2 Test (Low Altitude, Large Scale CIRVAP and Previous Map)

Map 2 Test (Appendix F, pp. 184-85) was based on Maps 1 and 2. Map 2 was a low altitude, large scale CIRVAP showing the south-west portion of the city of Calgary. The flying height for Map 2 was 9,900 m (33,000 feet) with a photographic scale of 1:60,000. A profile for Map 2 is given in Appendix B (Table 9).

Map 2 Test contained sixteen items. This test was designed mainly to determine each subject's ability to identify features on a large scale CIRVAP and to examine the ability of subjects to use Map 2 in conjunction with Map 1.

Map 2 Test items contained two levels of image discrimination: identification and analysis. In identification, subjects were asked to identify specific objects or features in the coverage area. For image analysis, subjects would then differentiate objects or features identified by explaining why. Map 2 was also enclosed in an acetate-cardboard envelope as was Map 1. Specific responses were recorded in the same way as for Map 1.

4. Landsat C1 Test

Landsat C1 Test (Appendix F, pp. 186-88) examined the ability of the subjects to recognize a Landsat image and how it is made, and to determine subjects' capabilities in identifying cultural, physical, and hydrological features similar to those identified on the road map and Maps 1 and 2. The Landsat C1 image showed the city of Calgary and surrounding areas (Appendix G, Plate 4).

The Landsat C1 test contained thirty-two items. These items were based on the Landsat C1 image. A profile of the Landsat C1 image is given in Appendix B (Table 9). The Landsat image was enclosed in an acetate-cardboard envelope with one for each subject to record his or her responses on the test items as previously done with Maps 1 and 2.

The questions were based on image recognition and interpretation of cultural, vegetation, and hydrological features of the image. The questions were so arranged that each subject's responses would reflect his ability to use previous information from the road map and the CIR vertical aerial photographs in order to identify features on the Landsat C1 image.

C. DATA COLLECTION

The RSOATB was administered to each subject in the sample. In the testing situation, only the subject and the examiner were present. After a period of instruction of nineteen and one-half hours, the RSOATB was given on April 27 and 28, 1982. The total testing time for each subject was approximately one hour and ten minutes.

The battery of tests, answer sheets, and acetate envelopes for each map were prepared in advance. A magnifying glass and indelible felt markers were available for each subject. Upon arrival for the test, each subject was given a map in the order of the sequence stated earlier. There was one laminated road map for each child, and one acetate envelope with a specified map for each child. The map was placed on the table in front of each subject with care to avoid glare on the acetate cover.

The non-directed method of observation was used only for Map 1 Part A Test. In this method, the children's ability to detect or simply state what they saw, would provide data as to how these

children could generally interpret a color infrared vertical aerial photograph.

For example, Map 1 was presented to the children for preliminary recognition and observation. Using Map 1, the investigator asked each child: Can you name five things you see in this image? The children were to examine the image and verbally reveal what features they saw. Their responses were recorded on their answer sheets by the investigator.

The directed method of observation was used with the remainder of the test battery. This method required the children to interpret a map in response to selected questions presented by the investigator.

For instance, each child was shown Map 2. The investigator pointed to a target and the child was asked; "What is this?" and, "How can you tell?" The children's responses were recorded as above. According to the target, some items required a slightly different phrasing.

Results from previous research using both methods demonstrated that elementary age children were able to obtain information using the directed method of observation.[7] In the Kirman studies, the directed method alone was used and seemed to be a satisfactory

[7] Long, 1953, p. 107; Bayliss and Renwick, 1966, p. 124-127; Dueck, p. 89.

approach for eliciting children's responses about Landsat C1 images.[8]

Each test item for every test in the map sequence was presented to the subjects by the researcher. Each subject's responses were recorded on answer sheets by the researcher. Some responses required delineation of specific targets on the acetate envelope by the subject. These were specified and marked or drawn by each subject.

Subjects were allowed a brief break to stretch and relax, but most of them wished to continue and complete the test. Each subject completed the test in approximately seventy minutes.

Scoring of the Remote Sensing Oral Achievement Test Battery

This instrument was comprised of five tests. Responses to each of these tests for each subject were recorded on answer sheets. This data was transferred into numerical form on response sheets for each test by alloting one mark for each correct response to each item. Responses included those demarcated on the acetate covered map envelope for which one mark each was also given. A few questions required more than one answer. For each of these reponses, one mark was given.

D. SUMMARY

This chapter is a description of the selection of the sample,

[8] Kirman, 1977, p. 55; Kirman, 1980, p. 5; Kirman, 1982, p. 7.

the Remote Sensing Oral Achievement Test Battery (RSOATB), the method of data collection, and the technique used for scoring the RSOATB.

The sample consisted of six children randomly selected from an urban grade four class by the investigator. The children were categorized by their teacher as below average, average, and above average. Their visual acuity was also determined by the classroom teacher. The Ishihara Color Blind Test conducted by the researcher and school nurse was used to determine color blindness. The Remote Sensing Teaching Unit (RSTU) provided preliminary experience with handling and interpreting a road map, color infrared vertical aerial photographs, and a Landsat C1 image, each representing the same scene.

The measuring instrument was the Remote Sensing Oral Achievement Test Battery (RSOATB). It was designed and prepared by the researcher to accommodate the multistage remote sensing approach in geographic studies. It was presented to the sample of grade four children by the researcher.

The RSOATB was comprised of the Road Map Test, Map 1 Test, Map 2 Test, and the Landsat C1 Test. Each test was based on its affiliated map and was addressed to each subject individually. The children's responses were quantified for analysis as described in the following chapter.

CHAPTER 1V

PRESENTATION AND DISCUSSION OF FINDINGS

This chapter presents the test results of those tests in Remote Sensing Oral Achievement Test Battery (RSOATB) noted in Chapter III. Their analyses provide the results and observations made for the total sample during the testing situation. The findings will be discussed according to each test. The following are the tests:

1. THE ROAD MAP TEST

The Road Map Test (see, Appendix F, p. 179) was based on a 1980/81 provincial road map (see, Appendix G, Plate 1, p. 191) of the city of Calgary. It consisted of eleven questions. The test asked for the children's recognition of the type of map, the children's sense of orientation of a road map, and their ability to detect and identify specific features for transferability to the remote sensing imagery used in this investigation.

Test Results

Table 2 provides a profile of the results of each subject in the Road Map Test, an item analysis, and the group percentage scores.

TABLE 2

ROAD MAP TEST

PUPIL PROFILE, ITEM ANALYSIS AND GROUP PERCENTAGE SCORES

Subjects ID Code Teacher Rating	A A+	D A+	C A	E A	B A-	F A-	Group Percentage Scores All	 A+	 A	 A-
1. What is this?	1	1	1	1	1	1	1.00	1.00	1.00	1.00
2. What place does it show?	1	1	1	1	1	1	1.00	1.00	1.00	1.00
3. Show me N.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
4. Show me S.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
5. Show me E.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
6. Show me W.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
7. Outline the boundary of the city of Calgary.	1	1	1	1	0	1	.83	1.00	1.00	.50
8. Show me a body of water.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
9. What is its name?	1	1	1	1	1	1	1.00	1.00	1.00	1.00
10. Show me a river.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
11. What is its name?	1	1	1	1	1	1	1.00	1.00	1.00	1.00
Total	11 100%	11 100%	11 100%	11 100%	10 91%	11 100%	98%	100%	100%	95%

1 Indicates correct response, one mark.
0 Indicates incorrect response, zero mark.

Table 2 reveals the performance scores among the A+, A, and A- children and shows no marked differences. As will be seen on Table 2, subjects knew what type of map it was. They were able to cope with basic orientation and simple identification questions related to the road map.

Analysis of Answers

Except for question 7, most children responded correctly to the test items. Question 7 called for outlining the boundary of the city of Calgary which was indicated by a yellow line on the map. Subject B found it difficult to follow the line with the finger as directed, and gave up saying, "I can't do it." Subject B's difficulty to follow the yellow boundary line may suggest a co-ordination problem, although no other evidence of this was observed. Subject B appeared bright and talkative yet tended to become easily distracted, so that attention to the task at hand seemed more difficult. Consequently, it was easier to say, "I don't know," or "I can't do it," rather than concentrate on the task. Subject B's difficulty also seemed to be the reluctance to work.

There seemed to be no individual differences in ability to deal with cardinal directions, and identification questions.

Each child responded correctly to the direction questions. It was observed by this examiner that upon picking up the road map,

the children oriented it before identifying features. Once this was done, the children seemed ready to proceed with the anticipated tasks. The children showed interest in the site by wanting to identify other targets and two children mentioned they had been to Calgary.

Conclusions of the Road Map Test

1. Inference can be made from Table 2 that according to the performance scores on the examination, these students are capable of using road map data for orientation, obtaining ground truthing information, and identification of physical features.

2. According to Table 2, direction questions present little difficulty. On the contrary, they appear to aid orientation, spatial awareness, and identification of targets by place and name.

This finding supports Brown et al. regarding the ability of 9 - 10 year old children to understand conventional signs and orientation. It does not support their result regarding the interpretation of physical features from topograhic maps by children under 14. It appears from the Brown studies that the kinds of questions asked and the type of maps used were quite complex for elementary children.

3. The findings of the Road Map test do not support Dale's conclusion on orientation that "children were much less interested in orientation and in particular those who rarely left the village

showed least concern with which way the map was turned."[1] In fact, Dale's general conclusion seems to reflect the children's sense of orientation even though in some cases their orientation was not correct. It would appear that the children needed a sense of orientation. Dale's findings seems to indicate that those who did demonstrate this ability moved on to interpreting other features on the map while those who did not depended on the photograph.

4. The findings of the Road Map Test support the use of road maps with iconic representations as demonstrated in the Kirman studies.[2] While these studies were specific to the use of Landsat C1 imagery, the Alberta road map was used as part of those experiments for orientation and identification of some targets by name.

5. It can be inferred from the Road Map Test that a road map may be used to provide direction and orientation, and for identifying features for subsequent multistage remote sensing application.

6. The directed method of observation appears to be sufficient for obtaining information from the road map.

[1] Dale, p. 173

[2] Kirman, 1977, p. 58; 1981, p. 224; 1982, p. 3.

2.1 MAP 1 PART A TEST

Map 1 (see, Appendix G, Plate 2, p. 193) was a high altitude, small scale CIRVAP of the city of Calgary. It was photographed on August 3, 1978. Map 1 Part A Test (see, Appendix F, p. 180) contained five items that required nine responses. It examined the children's understanding of basic aerospace information and their ability to detect and identify land cover features on Map 1. The children did not use the road map with Map 1 Part A or B Tests.

Test Results

Table 3 provides a profile of the results of each subject in Map 1 Part A Test, an item analysis, and the group percentage scores.

Table 3 shows the mean performance score of the three groups of children was 85% demonstrating a high level of proficiency in the categories mentioned earlier. This table indicates the A subjects performing at a higher level than the A+ group, and the A- subjects performing well above average level.

Analysis of Answers

Most of the children answered questions 1 and 2 correctly. In answering question 1, their responses were that it was an "infrared aerial photograph" and "it was made by a camera in a plane;" it was

TABLE 3

MAP 1 PART A TEST

PUPIL PROFILE, ITEM ANALYSIS AND GROUP PERCENTAGE SCORES

	Subjects ID Code	A	D	C	E	B	F	Group Percentage Scores			
	Teacher Rating	A+	A+	A	A	A-	A-	All	A+	A	A-
1.	What is this?	1	1	1	1	0	1	.83	1.00	1.00	.50
2.	By what was it made?	1	1	1	1	1	1	1.00	1.00	1.00	1.00
3.	What season of the year is this?	0	1	1	1	1	0	.67	.50	1.00	.50
4.	How can you tell?	0	0	1	0	0	0	.17	.00	.50	.00
5.	Name five (5) things you see on the maps.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
6.		1	1	1	1	1	1	1.00	1.00	1.00	1.00
7.		1	1	1	1	1	1	1.00	1.00	1.00	1.00
8.		1	1	1	1	1	1	1.00	1.00	1.00	1.00
9.		1	1	1	1	1	1	1.00	1.00	1.00	1.00
		7	8	9	8	7	7				
	Total	78%	89%	100%	89%	78%	78%	85%	83%	94%	78%

"made with infrared film taken by a plane;" and, "it was a picture taken by a plane." Subject B replied to question 1 that it was "infrared" and, "I forget" and was not awarded a correct mark. However, this same subject knew "it was taken from a plane." Subject B's forgetfulness or reluctance to participate at a more difficult level seems evident.

Subjects A and F appeared to have difficulty with question 3, and most of the other subjects had difficulty with question 4. These two questions were interrelated and required the children to apply their knowledge of the spectral signature of vegetation in their answers.

In responding to question 3, Subjects A and F said, "spring or summer." Since the answer required was "summer," a correct mark could not be awarded. Perhaps these subjects may have been confused by the quality of Map 1 since the outlying corners of the photograph were partially obscured. This could have reduced the degree to which they could discriminate the spectral signature of some of the land cover.

Even though question 3 was answered correctly by four subjects most of the children had difficulty with question 4 except Subject C. This child said, "you can see red, if it was winter you could see white." This subject received a correct mark for identifying the season by noting the vegetation as red. The other children's responses to question 4 were, "I forget," "it looks like bad farm-

land if it was summer, could be spring because there isn't much;" "there is no snow," and "it's not all white." These children received an incorrect mark.

During the teaching unit, the children had studied CIR vertical aerial photographs of the Edmonton site taken in July and August. A brief disscussion was given to what the land cover would look like in winter but more detailed work was learnt with the above summer photograph. No other seasonal imagery was used in the entire study. It appears that for questions 3 and 4, the children may have been confused by the new land form patterns of the Calgary site and the spectral signature of the terrain.

Question 5 required detection of features by the children. It attempted to use a non-directed approach but specifying the number of items to be responded to. It was hoped that this would indicate what kinds of features the children would generally observe. All of the children were able to detect and identify five features asked for in question 5, (see, Table 4, p. 76). They all identified one hydrological feature, at least one physical feature and one cultural feature. Only one child, Subject E, did not mention a physical feature.

Most of the subjects displayed curiosity, interest, and enjoyment in identifying the features of the Calgary site. This may be due to the variety and contrast of the landcover features. The children elected to use a magnifying glass from the table to

TABLE 4

CULTURAL, PHYSICAL AND HYDROLOGICAL FEATURES

DETECTED BY GRADE 4 CHILDREN FROM MAP 1 PART A TEST QUESTION 5

Subjects ID Code	Teacher Rating	Cultural	Physical	Hydro-logical
A	A+	Residential area,	Bare soil	River
D	A+	City	Farmland, trees	River, lake
C	A	City, airport	Farmland	River, lake
E	A	Houses, buildings streets		River, lake
B	A-	Houses, roads highways	Farmland	Bow River
F	A-	Warehouses, houses, rail-roads	Farmland	Water

determine what the land forms were.

They generally seemed to scan this CIRVAP photograph from 'down center,' then moved their eyes to the left, then to the top and right in a somewhat clockwise manner, then subsequently observing features in varying directions on the image (see, Figure 1, p. 78).

The children demonstrated intense interest by their observations and a few of them demonstrated this by pointing to the hills on the north of the map. It appeared that the bare hills in this area fascinated some of them, especially the boys. They peered through the magnifying glass to determine what this area might be and asked to spend more time interpreting this area. Time did not permit us to do so.

Conclusions of Map 1 Part A Test

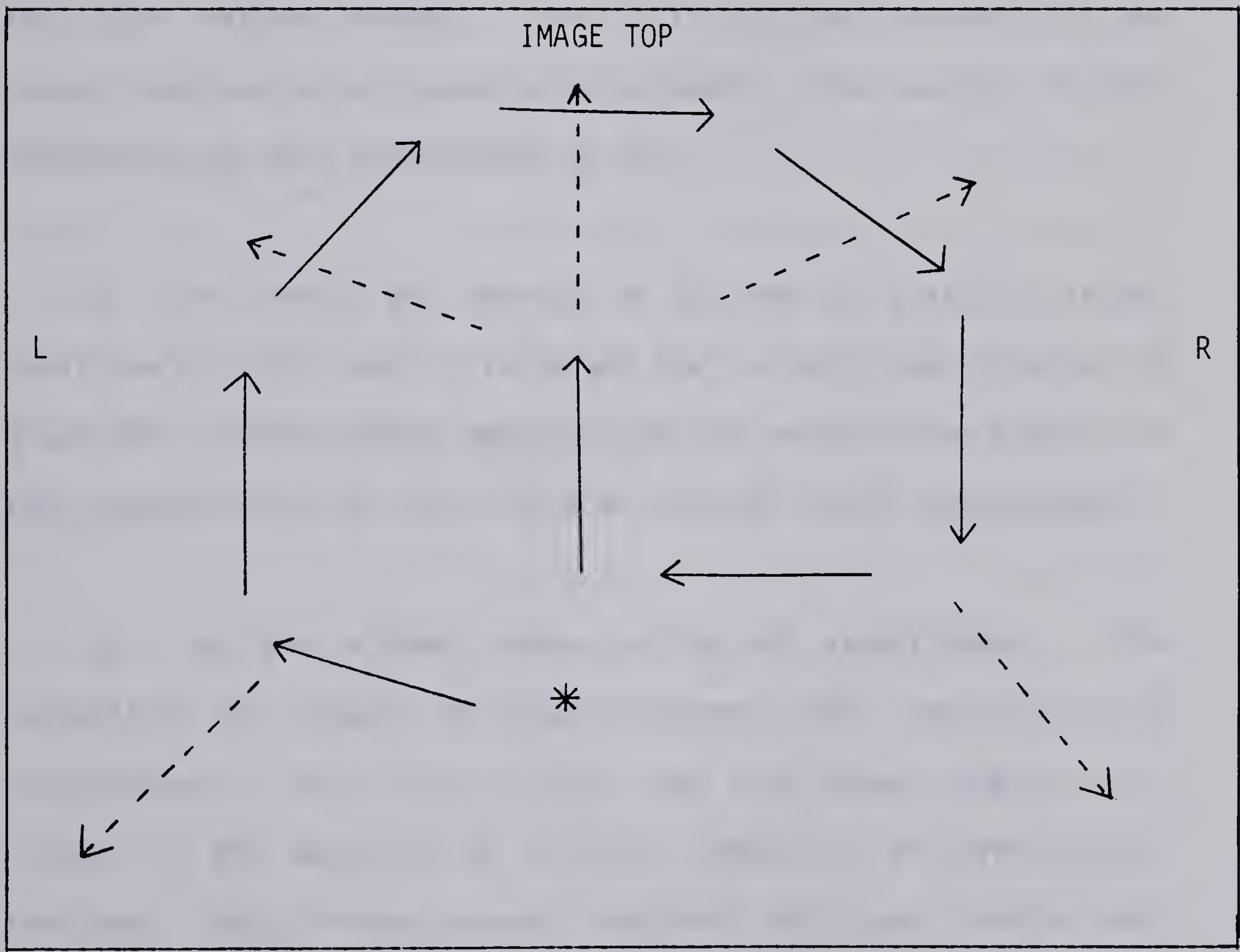
1. The results of Table 3 show that most of the children knew that the CIRVAP was a photograph taken with IR film from an airplane.

2. Inference can be made from Table 3 that the subjects tested seem to have transferred prior information of direction and orientation from the road map to Map 1 by their ability to position the map correctly and detect and identify features they mentioned such as "the Bow River;" "lake;" and "airport." Transference of information from the road map to Map 1 seems evident by the

FIGURE 1

GENERAL EYE SCAN MOVEMENT OF GRADE 4 SUBJECTS

USING A SMALL SCALE CIRVAP FOR DETECTION



Legend

———————>	First eye scan direction
- - - - - - - - ->	Observing in various directions
R	- Right of Image
L	- Left of Image
*	- Down Center, First Eye Contact

children's recognition of some of the same features on both the road map and Map 1.

3. There appears to be no difficulty by the children in determining the spectral signature of some cultural, physical, and hydrological features represented on a high altitude, small scale CIRVAP. This may be dependent upon the emphasis during teaching of the color infrared element. Some difficulty with recognizing the season and stating a reason were evident. The quality of this photograph may have contributed to this.

4. The variety and contrast of features on a high altitude, small scale CIRVAP seem to stimulate the curiosity and interest of grade four children which appear to be two contributing factors in the interpretation of color infrared vertical aerial photographs.

5. No one element seems to be of significance. The recognition of features by shape, pattern, color, and texture in combinations of two or more, rather than size alone, appears to be evident in the detection of cultural, physical, and hydrological features. This finding appears consistent with Long insofar that her sample of children used shape rather than size.[3]

6. The element of color infrared does not seem to present

[3] Long, 1953, p. 102.

many difficulties. In fact, it seems to improve the detection of features, depending again upon instruction and the quality of the photograph. The CIR concept was taught to the children in the RSTU (see, Appendix D, p. 150). The children's ability to detect features fairly quickly and to state by color the similarities or differences of features, seem to suggest a fair understanding of the CIR concept and spectral signature patterns.

It could be stated that prerequisite information regarding the visible and IR portions of the EMR in relation to CIR photography, through teaching, can help children understand and perceive the CIRVAP.

7. The non-directed observation appears effective for detection as is evident from item 5, Table 3, in which the children were required to name five features. Their variety of responses indicated their ability to detect features using Map 1. In detection, the interpreter observes what is present in the photograph.

There appears to be no difficulty by the children tested to interpret a high altitude, small scale CIRVAP for detection of cultural, physical, and hydrological features following an instructional unit.

8. Table 4 shows that the children were able to detect an almost equal proportion of cultural, physical, vegetational, and

hydrological features on a high altitude, small scale CIRVAP, but this may be dependent upon certain variables namely: related questions, children's ability, quality of the photograph, and the site of the image.

Previous research by Long and Dueck indicated that students perceive a larger proportion of cultural items than physical features. There appear to be no conclusive results regarding the proportion of cultural, physical, vegetational, or hydrological features since this may depend on the variables stated above.

9. Figure 2 seems to suggest that generally the children scanned Map 1 beginning at a 'down-center' position moving their eyes in a somewhat clock-wise pattern, then radiating into varying areas as interest dictated. This image-scanning pattern was observed by the investigator only during the detection of features in the non-directed observation.

Long had earlier stated that "the eyes of the child does not sweep as that of the photographer."[4] She indicated that the children's search should be guided for more identification. Dueck had observed that the children in her study "had a tendency to concentrate on one corner of the photograph and attempt to analyze detail."[5]

[4] Long, 1961, p. 334.

[5] Dueck, p. 78.

Map 1 was the small scale CIRVAP. It contained much detail. The scanning pattern of the children in this study seems to reflect their interest in studying the photograph. It would appear that if the children can scan a photograph in this manner without direction, perhaps with direction they may be able to obtain much more information. The directed observation method was used in the subsequent tests.

2.11. MAP 1 PART B TEST

Map 1 (see, Appendix G, Plate 2, p. 193) was a high altitude (37,621') small scale CIRVAP of the city of Calgary site. Map 1 Part B Test (see, Appendix F, pp. 181-183) contained thirty-one items. It was designed with a two-fold purpose: first, to determine the extent to which these children can apply prior knowledge from a road map to a CIRVAP and, secondly, to determine their ability to identify land cover and land use features on the above image.

Test Results

A profile of the results for each subject in this test, an item analysis, and the group percentage scores is given in Table 5. Table 5 shows a mean percentage score of 83% for the three groups in the total test. This score reflects a high proficiency level of the total group. It also reveals a higher performance level of the average group than the below average or above average group.

TABLE 5

MAP 1 PART B TEST

PUPIL PROFILE, ITEM ANALYSIS AND GROUP PERCENTAGE SCORES

Subjects ID Code Teacher Rating	A A+	D A+	C A	E A	B A-	F A-	Group Percentage Scores All	 A+	 A	 A-
1. What place does this Aerial Photograph show?	1	1	1	1	1	1	1.00	1.00	1.00	1.00
2. How can you tell?	1	1	1	1	1	1	1.00	1.00	1.00	1.00
3. Outline the city of Calgary.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
4. What is the area outside of the city?	1	1	1	0	1	1	.83	1.00	.50	1.00
5. How can you tell?	1	1	1	0	1	1	.83	1.00	.50	1.00
6. Outline the Glenmore Reservoir.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
7. Is its water clear/sed?	1	1	1	1	1	1	1.00	1.00	1.00	1.00
8. How can you tell?	1	1	1	1	1	1	1.00	1.00	1.00	1.00
9. Can you show the Bow River?	1	1	1	1	1	1	1.00	1.00	1.00	1.00

	Subjects ID Code	A	D	C	E	B	F	Group Percentage Scores			
	Teacher Rating	A+	A+	A	A	A-	A-	All	A+	A	A-
10.	Is its water clear/sed?	0	0	1	1	1	1	.67	.00	1.00	1.00
11.	All of it?	0	1	1	1	1	1	.83	.50	1.00	1.00
12.	How can you tell?	0	1	1	1	1	1	.83	.50	1.00	1.00
13.	Outline the Bow River.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
14.	What is "X"? (Airport).	1	0	1	1	1	1	.83	.50	1.00	1.00
15.	How can you tell?	1	0	1	1	1	1	.83	.50	1.00	1.00
16.	What is "G"? (Commercial services, warehouses).	1	0	1	0	1	0	.50	.50	.50	.50
17.	How can you tell?	1	0	1	0	1	0	.50	.50	.50	.50
18.	Can you find an old residential area? (marked by a red square).	1	1	1	1	0	1	.83	1.00	1.00	.50
19.	How can you tell?	1	1	1	1	0	1	.83	1.00	1.00	.50
20.	Can you find a new residential area? (marked by an orange square).	1	0	0	1	0	1	.50	.50	.50	.50

Subjects ID Code Teacher Rating	A A+	D A+	C A	E A	B A-	F A-	Group Percentage Scores All	 A+	 A	 A-
21. How can you tell?	1	0	0	1	0	1	.50	.50	.50	.50
22. What is "M"? (Road)	1	0	1	1	0	1	.67	.50	1.00	.50
23. How can you tell?	1	0	1	1	0	1	.67	.50	1.00	.50
24. What is "L"? (Golf Course).	0	1	1	1	0	1	.67	.50	1.00	.50
25. How can you tell?	1	1	1	1	1	1	1.00	1.00	1.00	1.00
26. What is "O"? (Trees).	1	1	1	1	1	1	1.00	1.00	1.00	1.00
27. How can you tell?	1	1	1	1	1	1	1.00	1.00	1.00	1.00
28. What is "Q"? (Downtown).	1	1	1	1	0	1	.83	1.00	1.00	.50
29. How can you tell?	1	1	1	1	0	1	.83	1.00	1.00	.50
30. What is "S"? (Railway)	1	1	1	1	0	1	.83	1.00	1.00	.50
31. How can you tell?	1	1	1	1	0	1	.83	1.00	1.00	.50
Total	27 87%	22 71%	29 94%	27 87%	20 65%	29 94%	83%	79%	90%	79%

Analysis of Answers

In responding to questions 1 and 2, all of the children identified the site of Map 1 as "the city of Calgary." They seemed to remember the shape of the city from the road map by recognizing the same shape on the photograph. Subjects D, E, and F recognized the city by saying, "I can see the Bow River" and the "Glenmore Reservoir." Here the children were using the proper names of the features instead of saying just "river" or "reservoir." Subjects A, B and C recalled that the city had the same shape as on the road map. It appears that prior information from the road map contributed to what appears as a personal feeling of knowing the site as the children began to interpret Map 1 for this part of the test.

For question 3, all of the subjects correctly delineated the city of Calgary with their felt markers. Some of them were quite attentive in their delineation between urban and agricultural land areas. They drew almost precisely the lines of the city boundary and took their time discriminating between which parts were agricultural and which were cultural. Yet, some of the children missed out sections of the fringe development of the city.

Two of the subjects were not as precise. They very quickly drew around most of the city area as if to show that they knew the answer at one glance. These children included the fringe sections of the city and, as well, some of the surrounding farmland.

Except for Subject A, all of the other children excluded the Calgary International Airport in mapping the city of Calgary. It seems that the children may have reflected on the Edmonton Landsat image taken in the teaching unit in which the international airport is situated outside the city.

The airport's linear pattern is different to the surrounding areas by the runways' spectral reflectance of white. Subject A who was diagnosed as partially color-blind included the airport in this mapping activity. This child may have observed the proximity of the south area of the airport to the city and decided the airport was part of the city or, his cue for color compensation may have helped him.

In answering question 3, some of the children excluded the southeast portion of the city which consists of a new residential area, new land development, and some industries. At first it seemed that they were using spectral signature (blue-green color) to aid in the delineation of urban and agricultural areas, as well as using linear patterns of the streets and residential sections, which was correct, but when this definite pattern changed for the new residential area, they seemed confused. It appears that the elements of pattern and texture aided their interpretation instead of color alone.

In answering question 4, the investigator directed subjects to the areas around the city. Most of the children recognized the

farmland as "blocks" or "divided up." Subject E referred specifically to the north area of the map just outside the city, as "rough, bare mountains." It would seem that this child was comparing the topographic features of the Calgary image with the flat farmland of the Edmonton site and did not understand the question or went beyond answering the question. Since the answer was "farmland," he was not awarded a mark.

For questions 6 - 13 inclusive, most of the children seemed to understand the spectral signature of clear and sedimented water on the CIRVAP image. All of them used the magnifying glass to determine the water conditions. They were all able to discriminate between the Glenbow Reservoir and the Bow River by name.

Question 14 - 23 and 28 - 31 regarding the interpretation of cultural features appeared to be answered correctly by most of the subjects. However, there seemed to be some difficulty with responding to questions 16 and 17 which asked for the spectral signature of industrial areas. Subjects D, E, and F described the area as "a lot of buildings joined up together" or "there are roads around the building." Although partially correct, a correct mark was given for saying "industries" or even "warehouses," since the children had identified "warehouses" as related to industries during the teaching unit.

Items 20 and 21 required the identification of new residential areas. It seems that the crescent patterns of these areas on Map 1

may have been confusing although they were more discernable on Map 1 of the Calgary site than Map 1 of the Edmonton site in the teaching unit. Perhaps, stronger emphasis during the teaching unit on the spectral signature of new residential areas should have been given.

For questions 22 and 23, the children indicated that it was a "highway" and "freeway," for reasons, namely: "it was bigger than a road;" "it had intersections," and "it is a line." The two children who responded incorrectly said it was a "railroad track" and "train tracks." There seems to be evidence of the children using linear patterns and size recognition.

In responding to questions 24 and 25, Subjects A and B referred to these areas a "a lot of trees," and "forests" because "it looked green." A correct mark was given for question 25 for determining the spectral signature of the 'greens' of the golf course even though they were unable to identify the golf course and were not awarded a correct mark for question 24.

Responses to items 26 - 31 reveal that all of the children were able to identify vegetation, downtown, and the railway tracks except Subject B.

Table 5 reflects a drop in performance for Subjects B and D. Subject B was absent for five days during the instructional sessions for both Maps 1 and 2. Subject D was absent for two

days during instruction for Map 1.

Conclusions of Map 1 Part B Test

1. Table 5 reveals an average performance score of 83% which demonstrates the capability of these children to use a high altitude, small scale CIRVAP for deriving information noted in this test.

This finding is in accord with the conclusion by Blaut and Stea that the vertical aerial photograph can be used by young children and that they can deal with map-like representations and display immense pleasure in doing so.[6] The finding also confirms Dueck's conclusion that children of grades four, five, and six can read vertical aerial photographs.[7]

2. It would seem that these children are capable of interpreting some cultural, hydrological, and physical features on a small scale, color infrared vertical aerial photograph. The degree to which each category is identified seems to be dependent on the structure of the questionaire, the child's ability, previous instruction, and the quality of the CIRVAP.

This finding does not support Long's conclusion that children will identify <u>more</u> cultural than physical features.[8]

[6] Blaut and Stea, in Bale, Graves and Walford, p. 97.

[7] Dueck, p. 89.

[8] Long, 1961, p. 336.

The finding supports the conclusion of Long[9] and Bayliss and Renwick[10] that children need guidance in the photographic detail for close study. This finding confirms Dueck's conclusion that the directed observation helped children to identify more features on the high scale photograph than the non-directed observation.[11]

3. There is evidence that the elements of color, shape, linear patterns, size, and texture, were used by the children to identify features. In some instances only one element was used - color, size, shape, or pattern as in the identification of some cultural, vegetation, and hydrological features. At other times a combination of two or even more were used. The sequence and degree to which one or more elements are used seem to be dependent on the questions asked in each category. Consequently, no claim can be made as to which one element is significant for CIRVAP interpretation.

4. The children did not question the element of the size of objects. Perhaps this was due to their understanding of the image formation and altitude of Maps 1 and 2 (used next in the RSOATB) during the teaching unit. At that time, it seemed evident to the children that on Map 1 objects would appear smaller than on Map 2.

9 Long, 1953, p. 107.

10 Bayliss and Renwick. In Bale, Graves and Walford, p. 129.

11 Dueck, p. 89.

This finding supports Long's[12] and Dueck's[13] conclusion that size is not as strong as shape recognition. However, as noted earlier, generally no one element can claim to be more significant that another since this depends upon the question presented and image being used, and very possibly emphasis of previous instruction.

5. The small scale CIRVAP seems to stimulate the children's curiosity, interest, and imagination. It was interesting to observe during the course of the teaching unit, that the children would at times pretend that they were flying above the table looking down at the photograph and identifying objects that appeared familiar. In some cases, unfamiliar targets were identified by color, shape, and/or pattern. During the testing, the children demonstrated similar enthusiasm as interpretation progressed.

These findings support Long's[14] and Dueck's[15] conclusion that children are interested in photographs showing a variety of features, and that emotion and imagination are important in the child's interpretation of the photograph.

[12] Long, 1953, p. 102.

[13] Dueck, p. 62.

[14] Long, 1953, p. 107.

[15] Dueck, p. 80.

Summary of Conclusions for Map 1 Parts A & B Tests

1. Inference can be made from Table 5 that the grade four subjects were generally able to use prior information from the road map, as shown by their ability to identify the site by name and identify specific physical features also observed in the road map by name. It appears that the use of the road map provided some ground information and orientation that helped the children in their subsequent interpretation of Map 1.

2. The results of Table 5 reveal a high performance for most of the children in their ability to identify cultural, vegetational, and hydrological features except for Subjects B and D. These children were absent during periods of instruction for Map 1. However, their results indicate a reasonable passing score.

3. Table 5 reveals that grade four children can use a small scale CIRVAP to identify urban and agricultural features. This may be dependent upon the emphasis during teaching.

4. The elements of color, shape, size, linear patterns and texture are used sometimes singularly or in combination with the interpretaion of a high altitude, small scale CIRVAP depending upon the question presented.

5. The element of CIR does not appear to present much difficulty in the interpretation of Map 1. It conversely, appears to facilitate this concept provided that it is taught to the children (see, Appendix D for teaching unit). The children in this

study seemed to detect and identify cultural, physical, vegetation, and hydrologic features with few difficulties. For example, they said, "trees are rough, and dark red;" "water looks black;" "soil looks greenish;" and "new parts (of the city) look bluish."

6. It can be stated that the children's eye scanning movement or the way they look at the color infrared vertical aerial photograph can influence the number of features they identify in both the non-directed and directed methods.

3. MAP 2 TEST

Map 2, (see, Appendix G, Plate 3, p. 195) was a low altitude (33,000') large scale CIRVAP of the southwest portion of the Calgary site. Map 2 Test (see, Appendix F, pp. 184 - 185) contained sixteen items. This test was designed mainly to test each subject's ability to identify features on a large scale CIRVAP and explain why, and to examine their ability using conjunctly two scales of color infrared vertical aerial photographs of the same areas, namely Maps 1 and 2. Map 2 was taken on August 9, 1981.

Test Results

An examination of Table 6 reveals that the sample as a whole achieved a satisfactory level of performance with an average of 78% in the use of Map 2. Evidence from Table 6 indicates a severe drop in performance for Subject B. This (A-) subject was absent for five instructional sessions during Map 1 and Map 2 instruction. Table 6 reveals a high score for Subject F described by the teacher

TABLE 6

MAP 2 TEST

PUPIL PROFILE, ITEM ANALYSIS AND GROUP PERCENTAGE SCORES

	Subjects ID Code	A	D	C	E	B	F	Group Percentage Scores			
	Teacher Rating	A+	A+	A	A	A-	A-	All	A+	A	A-
1.	Compare Map 1 and Map 2. Show me where this (W) area of Map 2 is on Map 1.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
2.	What direction is it from the rest of the city? (West)	0	1	1	1	0	0	.50	.50	1.00	.00
3.	What is "T"? (Single homes).	1	1	1	1	0	1	.83	1.00	1.00	.50
4.	What is "V"? (Apartment)	1	1	1	1	0	1	.83	1.00	1.00	.50
5.	How can you tell the difference?	1	1	1	1	0	1	.83	1.00	1.00	.50
6.	What is "C"? (Schoolyard)	1	1	1	0	0	1	.67	1.00	.50	.50
7.	How can you tell?	1	1	1	0	0	1	.67	1.00	.50	.50
8.	Mark a "C" at another school.	1	1	1	1	0	1	.83	1.00	1.00	.50

Subjects ID Code / Teacher Rating	A A+	D A+	C A	E A	B A-	F A-	Group Percentage Scores All	A+	A	A-
9. Show downtown.	1	1	1	1	0	1	.83	1.00	1.00	.50
10. Draw a square to show part of downtown.	1	1	1	1	0	1	.83	1.00	1.00	.50
11. What kind of buildings do you see?	1	1	1	1	0	1	.83	1.00	1.00	.50
12. How can you tell?	1	1	1	1	0	1	.83	1.00	1.00	.50
13. What time of day is it?	1	1	0	0	1	1	.67	1.00	.00	1.00
14. How can you tell?	1	1	0	0	1	1	.67	1.00	.00	1.00
15. Compare Map 1 and Map 2, the west portion of the city. What do you observe?	1	1	1	1	0	1	.83	1.00	1.00	.50
16. What changes do you see?	1	1	1	1	0	1	.83	1.00	1.00	.50
Total	15 94%	16 100%	14 88%	12 75%	3 19%	15 94%	78%	97%	81%	56%

as having below average ability. There is evidence from Table 6 that the majority of the children demonstrated the ability to identify features on Map 2 and use it in conjunction with Map 1.

Analysis of Answers

An analysis of the research items in Table 6 indicates the ability of the students to use Map 2. In responding to question 1, all the children could identify Map 2's site on Map 1. The recognition of the Glenmore Reservoir by its shape appeared to be an easy task. Question 2 reflected some difficulty as the concept of compass direction became more complicated. Although the children were able to locate the southwest target site of Map 1 on Map 2, some of them had difficulty with this direction question. Perhaps the phrasing of the question may have caused some misunderstanding of the problem.

Questions 3 - 12 inclusive, required subjects to identify residential and commercial features according to Anderson's Level 111 category of land use.[16] A letter representing each target was written on the acetate cover of Map 2. The children were to interpret what the target was. Subjects described target "T" as "a whole bunch of houses;" "old brick homes;" "old residential areas with hours;" "regular homes;" and "small houses." Subject B identified it as "apartments," and was not awarded a correct mark.

[16] Anderson, et al. A Land Use and Land Cover Classification System for Use with Remote Sensor Data, USGS Professional Paper, (Washington, D.C.; GPO 1976), p. 10.

Most of the children identified target "V" as apartments because "apartments are longer than houses;" "apartments have no driveways;" "flats (apartments) are in line," (this subject was from Australia); "the apartments are in long lines all over, spread apart." Subject B referred to target "V" as "warehouses," and was not awarded a correct mark.

It would seem that for identifying residential features, size became significant, even for Subject B who was absent during the teaching unit of Map 2. The use of linear patterns, texture and shape is evident from their responses.

In responding to question 6 which called for the identification of a school and schoolgrounds, most of the children were correct except Subjects B and E. Subject B did not know and gave up; Subject E described it as a "shopping centre with a parking lot." It seems that this child may have been paying closer attention to finer details such as the size of the building and the texture of the playground. The investigator responded that it was a "school and schoolyard," upon which the child promptly identifed another similar target. It appears from this target that the playground may recently have been mowed, hence, the interpretation of a "parking lot." Perhaps a less complicated target of a school site could have been chosen among the many others on the photograph.

For questions 10, 11, and 12, except for Subject B, most of the children delineated and correctly identified the commercial

features. For question 13, their ability to recognize shadows seemed to provide clues for observing the height of the buildings and the time of day when the image was taken. Subjects C and E knew that the image was taken in the morning but were unable to apply directional observations. Since questions 13 and 14 were interrelated, correct marks were not awarded. However, there seems to be evidence that the children used shadows as clues for identifying the size and shape of certain buildings.

Except for Subject B again, all of the other children responded correctly to questions 15 and 16. Using the magnifying lens, the children carefully observed the fringe developments on the west of Map 1 and Map 2. The children observed the target sites (the west portion of the city) on both maps. They referred to this area as smaller on Map 1 than on Map 2. For question 16, the children appeared to understand the spectral signature of land development. Some of them described this land cover as "white;" "making the city bigger by building construction;" and "the city is adding on." The children did not suggest it as a new residential area, but most of them stated that Map 2 was taken after Map 1 because "Map 1 is missing some areas; and it does not show anything added to." The children appeared to make use of this multidate information for their assessment of change detection.

Conclusions of Map 2 Test

1. Inference can be made from Table 6 that the majority of the group tested can interpret a low altitude, large scale color infrared vertical aerial photograph for deriving information noted in this test.

This finding supports Blaut's statements that young children can use iconic representations such as the aerial photograph and that mapping behavior is a natural ability.

This finding also supports the conclusion of Dueck's study that grade four, five, and six children can read vertical aerial photographs.

2. The results of this test indicate that the majority of the group tested can use a high altitude, small scale CIRVAP in combination with a low altitude, large scale CIRVAP of the same location to distinguish some differences between them, and some similarities between them.

The children's ability to detect, identify, and map features on Map 1 seemed to have helped them to further interpret land use patterns observed on Map 2. It would appear that with the directed method of observation, most of the children were able to transfer information from one CIRVAP to another, each representing the same region.

This finding supports the conclusion of Dueck's study in which

she used photographs of varying scales and found that the directed question method helped children to identify more features in the "high scale photograph."[17]

This finding further supports the conclusion of Long,[18] and Bayliss and Renwick[19] that children of all ages are able to discover what is geographically significant in pictures more readily if their search is guided.

3. The results of Map 2 Test indicate that size recognition seems more significant in the interpretation of cultural features in Map 2, but not as significant for Map 1. For example, during Map 2's interpetation several children described residential buildings as being "smaller, while apartments were tall, big buildings like skyscrapers." As mentioned earlier, this finding may reflect the children's responses generated from the type questions presented to them.

In using Map 2, other elements such as texture, pattern, and shadows, seem to help the children determine some features. For instance, in responding to question 3, Subject F replied that "'T' shows smaller, fuzzy, dots for homes while 'V' is longer, not fuzzy, and have no driveways." This subject also referred to "tall buildings" as being "like skyscrapers with big shadows." Most of the other children's responses reflected similar observations.

[17] Dueck, p. 66.

[18] Long, 1961, p. 337.

[19] Bayliss and Renwick. In Bale, Graves and Walford, p. 129.

This finding about size for Map 2 is in contrast to the earlier findings in this study, (No. 4, pp. 91-92) where the recognition of shape, pattern, color, and texture appears to be stronger than the recognition of size in the use of Map 1, the small scale CIRVAP.

4. This finding supports the statement of Blaut and Stea, that the interpretation of the aerial photograph should not be withheld until children have learned the writing and arithmetic of map legend and scale.[20]

5. Table 6 indicates that the color infrared concept was easily understood by the grade four children. They demonstrated the ability to determine the spectral signature of features by identifying the various cultural, hydrological, and vegetation features represented in both Maps 1 and 2. The children showed interest during the teaching unit with CIR photography and wanted to know whether it was possible to use color infrared film in the ordinary camera.

This finding supports the statments made by some researchers using vertical aerials and color photographs that color provides an additional cue for recognition and appears to make the task of identification somewhat easier.[21]

[20] Bale, et al. p. 97.

[21] See, Dueck, p. 92; Hanna, p. 31; Jahoda, et al. p. 210; J. Jarolimek, Social Studies in Elementary Education,Fifth Edition, New York: MacMillan Publishing Co. 1977, pp. 171 - 172 and pp. 185 - 186; Riffel, pp. 554 - 555; Reeves et al. pp. 931 - 933.

Although color infrared is significantly different from a natural color image, the children seemed to be able to deal with it. Kingston stated that "young children pay comparatively little attention to color as such when identifying and reacting to objects in normal everyday situations."[22] Rather, when children do pay attention to color in the environment, they do not seem to stereotype their color observation. Perhaps, this ability to do so may have helped the children in this study to readily understand the CIR concept which seems to assist the interpretation of Maps 1 and 2, the color infrared vertical aerial photographs used in this study.

6. Tables 5 and 6 show the performance of Subject E, diagnosed as partially color-blind. Subject E's overall mean score of 81% for Map 1 Parts A and B and Map 2 Tests gives an indication of his ability to interpret small and large scale CIRVAP. How the child is able to compensate for this deficiency is beyond the scope of this study.

[22] Kingston, p. 9.

1V. LANDSAT C1 TEST

The Landsat C1 image (see, Appendix G, Plate 4, p. 197) was a high altitude, small scale color composite satellite image of the city of Calgary (920 km). The Landsat C1 Test (Appendix F, pp. 186 - 188) was constructed upon this image. It contained thirty-two items. The test was designed, first, to determine the ability of these children to recognize a Landsat image and how it is made; second, to determine the capability of these children to identify cultural, physical, and hydrological features similar to those identified in the road map and Maps 1 and 2. The Landsat C1 image was taken July 16, 1979.

Test Results

An examination of Table 7 reveals for the subjects a performance level of 82%, thus demonstrating their capability to interpret the Landsat image and derive geographic information from it. It would seem that the children were able to identify cultural, hydrological, and physical features using the spectral signature of features previously learned from both Maps 1 and 2, but they had difficulties with features new to them. Perhaps more emphasis of image interpretation clues during the instruction phase would have aided interpretation.

TABLE 7

LANDSAT C1 TEST

PUPIL PROFILE, ITEM ANALYSIS AND GROUP PERCENTAGE SCORES

Subjects ID Code Teacher Rating	A A+	D A+	C A	E A	B A-	F A-	Group Percentage Scores All	 A+	 A	 A-
1. What is this? (Landsat Image)	1	1	1	1	1	1	1.00	1.00	1.00	1.00
2. By what was it made? (Sat.)	1	1	1	1	1	1	1.00	1.00	1.00	1.00
3. What season of the year is it?	0	0	1	0	1	0	.33	.00	.50	.50
4. How can you tell?	0	0	1	0	1	0	.33	.00	.50	.50
5. What is this area called? (city of Calgary).	1	1	1	1	0	1	.83	1.00	1.00	.50
6. How can you tell?	1	1	1	1	0	1	.83	1.00	1.00	.50
7. Show other towns.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
8. How can you find out the names of these other towns?	1	1	1	1	1	1	1.00	1.00	1.00	1.00
9. Show the Bow River.	1	1	1	1	1	1	1.00	1.00	1.00	1.00

Subjects ID Code Teacher Rating	A A+	D A+	C A	E A	B A-	F A-	Group Percentage Scores All	 A+	 A	 A-
10. What can you tell me about the water in the Bow River?	1	1	1	1	1	1	1.00	1.00	1.00	1.00
11. How can you tell?	1	1	1	1	1	1	1.00	1.00	1.00	1.00
12. What is "A"? (Clouds).	0	0	0	1	0	1	.33	.00	.50	.50
13. How can you tell?	0	0	0	1	0	1	.33	.00	.50	.50
14. What is "C"? (Lake)	1	1	1	1	1	1	1.00	1.00	1.00	1.00
15. What is "D"? (Cloud Shadow)	0	0	0	1	0	1	.33	.00	.50	.50
16. How can you tell?	0	0	0	1	0	1	.33	.00	.50	.50
17. Show the Glenmore Reservoir.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
18. What river flows into the Glenmore Reservoir?	1	1	1	1	1	1	1.00	1.00	1.00	1.00
19. Outline where the Bow River starts.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
20. Show where there are mountains.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
21. How can you tell?	1	1	1	1	1	1	1.00	1.00	1.00	1.00

	Subjects ID Code Teacher Rating	A A+	D A+	C A	E A	B A-	F A-	Group Percentage Scores All	 A+	 A	 A-
22.	Show an area that looks like snow. (Glaciers).	1	1	1	1	0	1	.83	1.00	1.00	.50
23.	How can you tell its snow (glaciers) and not clouds?	1	1	1	1	0	1	.83	1.00	1.00	.50
24.	Show an area in the mountains with no snow.	1	1	1	1	0	1	.83	1.00	1.00	.50
25.	Why would an area in the mountains have snow, and another area not have snow?	1	1	1	1	1	1	1.00	1.00	1.00	1.00
26.	Circle an area of thick vegetation that is not farmland.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
27.	How can you tell there are forests in this area (dark red to purple) on C1?	1	1	1	1	1	1	1.00	1.00	1.00	1.00
28.	Mark an area of forest with an X.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
29.	What is this checkered area? (Lumbering).	0	1	0	0	0	0	.17	.50	.00	.00

Subjects ID Code Teacher Rating	A A+	D A+	C A	E A	B A-	F A-	Group Percentage Scores All	 A+	 A	 A-
30. Draw a line to show where the mountains end.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
31. Draw a line to show where the forests end.	1	1	1	1	1	1	1.00	1.00	1.00	1.00
32. What do you call these three regions? (Mountains, forest, prairies).	1	1	1	1	1	1	1.00	1.00	1.00	1.00
Total	25 78%	26 81%	27 84%	29 91%	22 69%	29 91%	82%	80%	88%	80%

Analysis of Answers

For questions 1 - 2, the children accurately described the type of image they were using and how it was obtained. During the teaching unit they were fascinated with learning about the satellite and its mechanical ability to produce images of the Earth.

In responding to questions 3 and 4 which required the spectral signature of vegetation, some confusion was observed. This may be due to the orange tone given to the Calgary test image, whereas the Edmonton image used during the teaching unit had a red tone. Perhaps this variation could have been specified at the beginning of the examination. Two of the children knew it was summer but could not understand the change from the usual red reflectance pattern of healthy vegetation to one of orange. Subject F said, "it was fall because the fields are orange." It would seem that in the interpretation of Landsat C1, close attention by the children is given to color.

In responding to items 5, 6, and 7, the children were able to identify the urban areas on the image by using the same spectral signature of these areas as on the CIR vertical aerial photographs. Almost all the children referred to the "greyish-blue color" of the cities and towns. Some of the children further identified the city of Calgary as the "same shape as in the aerial photograph." A few of them knew it was Calgary by pointing out the "Glenmore Reservoir" and "the Bow River going through it."

For items 9, 10, and 11, the children correctly outlined with their felt pens the Bow River starting from the mountains and going through the city. All the children identified the mountains which were a new feature. Some of them mentioned they had been to Banff. The children seemed to identify hydrological features quite easily by applying the spectral signature of water previously learned with the aerial photographs. All of them said the water was "clear," and "not sedimented" because it was "black."

For items 12, 13, 15, and 16, there was some confusion. Three children correctly identified item 12 as clouds with shadows underneath. Subjects A and D interpreted it as "snow" because it was "greyish-white."

Although all the children correctly identified item 14 as a "lake," with item 15 there appeared to be considerable confusion. Only two subjects correctly identified it as a cloud shadow. The others stated it was a "lake" because it was "black."

In responding to items 17 - 19, the children had no difficulty. Item 17 was easily recognized by its shape, and for item 19, they all traced the river from the mountain to the low land.

It was felt by the researcher that items 20 - 25 may be quite difficult since the mountain region and glacial studies would be new to them. It was out of curiosity again that these items were

presented. However, the children's responses did not indicate as much difficulty as anticipated.

For item 20, the children seem to easily recognize the mountains. They stated that "the mountains looked high, rough, and crumply, like grey paper;" "they look greyish white;" "they have peaks;" "some are tall and have shadows;" "they look bumpy, some parts are brown and white;" "some parts have snow on top of them."

The children's responses to items 22 - 25 were quite interesting. For item 22, they easily identified an area that looked like snow. None of the children mentioned 'glaciers' which would have been more correct. Their responses for items 23 were as follows: "clouds don't sit on top of mountains;" "clouds would have shadows in the ditches;" "snow sits on top of a mountain." Items 24 and 25 were interrelated. Except for Subject B, all of the children indicated an understanding of elevation. Subject B seemed confused with the spectral signature of mountains and responded incorrectly. This child subsequently answered question 25 correctly.

Questions 22 - 25 attempted to probe the children's ability to observe various elevation levels and identify features on a new land cover area shown on the satellite image. This information could lead to the understanding of important geographic concepts related to glaciation, hydrology, and water studies later applied to forestry, agriculture, and urban studies.

Questions 26, 27, and 28 were considered difficult since such forest areas were not identified on the Edmonton Landsat image in the teaching unit. However, the children were able to identify the evergreen forest areas as forests because "they are near the mountains;" "they are bumpy and have a dark color;" and "forests are bumpy and dark red." The children did not remember the term 'evergreen' which had been introduced during the teaching unit.

Question 29 was a performance question to find out whether they could identify a lumbering area. It was presented to the children out of curiosity. Lumbering and coal mining were mentioned as natural resources in the teaching unit. Only coal mining in the Battle River area was identified during instruction about the Landsat C1 image. No further discussion or pattern identification about lumbering was done in the teaching unit.

Subject D was the only one who said "it was a clearing;" and received a correc mark. However, the other children's responses that it was "farmland;" "buildings;" "sand;" and "campers;" gave an indication of their understanding about spectral reflectance patterns of soil and cultural features on the satellite image.

For questions 30 - 32, all of the children correctly delineated the geographic regions and described them as: mountains (the Rockies), forests, and farmland.

<u>Conclusions of Landsat C1 Test</u>

1. These children are able to identify cultural, vegetation, and hydrological features on a C1 image.

This finding supports the results of Kirman's studies,[23] Kirman and Goldberg,[24] Smith,[25] and Burke,[26] that elementary children can use Landsat C1 images.

2. Table 7 indicate that these children can determine and use the spectral signature of cultural, hydrologic, and vegetation features from the color infrared vertical aerial photographs for subsequent identification of features in the Landsat C1 image. It would seem that such multistage interpretation provides a gradual learning process of concepts and the retention of ideas.

3. These children seem to be able to use the following elements in the interpretation of Landsat C1 imagery, namely: color, texture, pattern, site and association of certain targets. The proportion to which these elements are used appears to depend on which category the question is related to, namely: cultural, vegetation, geologic, or hydrologic. For example, the children described forests as "bumpy and dark red," thereby using two elements of texture and color.

[23] Kirman, 1977, p. 63.

[24] Kirman and Goldberg, Dec. 1979, p. 281; May 30th. 1980, p.8

[25] Smith, p. vi.

[26] Burke, p. 40.

4. It was earlier found for Map 2, that shadow was used by the children to identify tall buildings. Shadow recognition seemed to be of help then. With the Landsat C1 image, the children may have been confused with identifying the lake nearby then subsequently observing a similar shape namely, the cloud's shadow. While shadows are familiar features, clouds' shadows are seldom observed and perhaps more difficult to discern on the satellite image.

Cloud cover was not observed on the the Landsat instruction C1 image instruction and therefore was not taught. Since cloud cover is present in many Landsat images, this concept could have been mentioned during the teaching unit.

5. The results of Map 1 Parts A and B Tests earlier, suggested that color and shape were significant for interpretation while Map 2 test results indicated that size, linear patterns, texture, and shadow were significant.

The results of the Landsat C1 test reveal that for certain macro environmental features, elements such as color, texture, pattern, shape, site and association are important for interpretation but that no one element is more significant than the other. Size does not seem to be as significant for Landsat as it was for Map 2. Perhaps this may be due to either an understanding of Landsat's characteristics during the teaching unit from which the children accepted features on the satellite map as being small, or that few questions on the Landsat C1 test generated responses

about size. During the teaching unit, the children were amazed at the smallness of some features such as the city, rivers, mountains, farmland and the Glenmore Reservoir. This excitement was not observed during the Landsat C1 test.

6. The results of the children's ability to interpret Landsat C1 imagery appear to depend on the instructional emphasis of image interpretation elements namely: size, shape, color, texture, pattern, shadow, site and association and the teacher's knowledge.

7. Table 7 indicates a mean percentage of 82% reflecting a high average mark evidently indicating the children's ability to interpret the Landsat C1 image and as well, reflecting what was taught to them. While there were some difficulties with a few questions which were given out of curiosity, these results seem to indicate that the children learnt what was taught to them but had problems with concepts that were not dealt with during the teaching unit.

This finding supports that of Long's which stated that children will read into pictures what they have been taught.[27]

8. There is evidence from Table 7 that the partially color blind male child is able to interpret a Landsat C1 image.

[27] Long, 1961, p. 325

V1. ADDITIONAL CONSIDERATIONS

1. An examination of Table 8 reveals a satisfactory level of performance on each of the tests in the Remote Sensing Oral Achievement Test Battery (RSOATB) for all of the subjects except Subject B. This subject rated by the classroom teacher as below average scored 64% which would be considered a failing level. Surprisingly enough, Subject F, also rated by the teacher as below average, scored 91% which was the second highest mark in the total test.

Table 8 indicates for Subject B an absence of five days during the teaching of Map 1. This absenteeism may have contributed to the variation of performance for Map 1 as well as Map 2 since the interpretation of Map 2 seems dependent upon the previous learning of Map 1. This observation also reflects the progression of learning remote sensing concepts in a multistage sampling strategy as indicated in Subject B's performance for Map 1 and Map 2.

2. Table 8 reveals the significance of the influence of teaching using remote sensing materials and related concepts. These children were exposed to some new and difficult concepts, as well as a battery of questions, yet most of them performed at a reasonably satisfactory level. Long's statement that children will read into pictures what they have been taught is evident.[28]

[28] Long, 1961, p. 325

TABLE 8

SUMMARY OF MEAN PERCENTAGE (%) SCORES FOR EACH TEST IN THE RSOATB

Subjects ID Code	Age	Sex	Teacher Rating	Road Map 11	Map 1 Part A 9	Map 1 Part B 31	Map 2 16	Landsat C1 32	Total % 99
A	9.8	F	A+	100	78	87	94	78[c]	87
D	9.6	M	A+	100	89[a]	71	100	81	88
C	9.4	M	A	100	100	95	88	84	93
E[d]	10.1	M	A	100	89	87	75	91	88
B	10.1	F	A-	91	78	65[b]	19[b]	69	64
F	9.4	M	A-	100	78	94	94	91	91
			$\overline{X}=$	98%	85%	83%	78%	82%	85%

a - Child absent for two instructional sessions.
b - Child absent for five instructional sessions during Map 1 and Map 2 instruction.
c - Child absent for two instructional sessions.
d - Child diagnosed as partially color blind.

3. Inference can be made from Table 8 that while the children's ability levels may be reflected in learning to interpret color infrared vertical aerials, a road map, and Landsat C1 images, some children will probably perform at higher or lower levels than expected depending on various factors such as: small group learning situation, emphasis on the learning material, and the teacher's knowledge and background.

This finding supports Kirman's conclusions regarding the general ability of grade three children to use Landsat C1 images and grade six children using Landsat MSS data in which the children's ability, background knowledge of the teacher, and emphasis on the learning material were factors determining the children's performance.[29]

4. Table 8 reveals that Subject E, the child diagnosed as partially color blind can interpret color infrared vertical aerial photographs, a road map, and Landsat C1 imagery. In comparison with the other children, Subject E rated by the teacher as of average ability achieved a satisfactory level of performance with a score of 88%.

[29] Kirman, 1977, p. 63; and Kirman, 1982, p. 11.

V11. SUMMARY OF THE FINDINGS

1. The Road Map Test sought to determine these children's recognition of a city road map, their sense of orientation in its use, their ability to use the road map to supplement ground truthing information that may be transferable to other remote sensing imagery, and provide initial experience with the aerial perspective.

Analysis of the result found that they are able to identify a city road map, to determine cardinal directions and orientation, and to identify features using a road map.

2. Map 1 Parts A and B Tests attempted to determine the children's ability for the transferability of prior information form the city road map to Map 1, and the ability to interpret a high altitude, small scale color infrared vertical aerial photograph.

It was found that grade four children were able to recognize a color infrared aerial photograph and interpret cultural, physical, and hydrological features. There is evidence that prior use of a road map can aid in the interpretation of high altitude, small scale CIR vertical aerial photographs by supplementing ground information which may not be readily available. It was also found that elements of map interpretation and emotional factors, such as interest and imagination, are of value in the interpretation of the

small scale color infrared aerial photograph. The findings indicate that these children can interpret a high altitude, small scale CIRVAP.

3. Map 2 Test was designed to examine the ability of these grade four children to interpret a low altitude, large scale color infrared vertical aerial photograph and use it with the high altitude, small scale map to derive information. There is evidence of this ability.

4. The Landsat C1 Test sought to determine the ability of these children to interpret the Landsat C1 image using prerequisite information from the road map and Maps 1 and 2.

Results indicated that the children are able to interpret Landsat C1 images and use prior information from color infrared vertical aerial photographs to further identify targets and understand macro scaled environmental features represented in the Landsat C1 image.

5. It has also been found that partial color blindness of a male grade four child apparently did not interfere with his ability to interpret a road map, color infrared vertical aerial and Landsat C1 images.

CHAPTER V

SUMMARY, IMPLICATIONS, AND SUGGESTIONS FOR FURTHER RESEARCH

This was an exploratory study to investigate the ability of grade four children to interpret color infrared vertical aerial photographs and use them in conjunction with Landsat C1 imagery and a road map, each representing the same site.

Research in the use of black and white vertical aerial and Landsat C1 imagery reveals that elementary school children can interpret these materials and use them for obtaining relevant geographic information. CIR vertical aerials and Landsat imagery are found in the government of Alberta's elementary social studies texts but no studies were discovered by the investigator in children's use of CIR vertical aerials.

A review of the literature examined studies in map skills, road maps, black and white vertical aerials, one color stereogram, color photographs, and Landsat C1 imagery in the elementary grades.

Summary of the review of the Literature

A summary of the review is as follows:

1. Map skills contribute to the intellectual development of the elementary school child and provide the means for children to

acquire specific and pertinent data for geographic and environmental learning.

2. The road map contains some basic geographic information which could provide ground truth information when on-site study may not be readily possible and as well, assist the development of simple map interpretation skills.

3. Mapping is a natural ability with young children. In map learning this ability could be enhanced with the use of iconic representation of the environment.

4. Black and white vertical aerial photographs and satellite images such as Landsat C1 are iconic representations which can be used to depict reality. They could therefore facilitate better understanding of geographic and environmental concepts than conventional topographic maps used alone.

5. The interpretation of black and white vertical aerials and Landsat C1 imagery is enhanced with the effective use of certain map interpretation elements. These elements can be used either individually or in combination depending upon the task. They are as follows:

a. size
b. shape
c. shadow
d. color/tone
e. texture
f. pattern
g. site
h. association
i. resolution

6. Some researchers had indicated that various factors seem to assist children's interpretation of iconic representations for geographic and environmental learning.

These factors are:

a. The use of multiple maps.

b. Maps showing a variety of detail.

c. The directed method of observation.

d. The child's interest, emotion and imagination.

e. The background knowledge of the teacher.

f. Small group learning situation.

g. Image-related questions.

7. There is evidence from the related literature that very young children can interpret black and white vertical aerial photographs, that children from the grade three level can interpret Landsat C1 imagery, and that elementary children may be able to use the road map for deriving some geographic information.

Summary of Procedure

The main instrument of the study was the Remote Sensing Oral Achievement Test Battery (RSOATB) which was constructed, administered, and analysed by this investigator.

The RSOATB was used to examine the ability of a sample of grade four children to interpret a road map, CIR vertical aerial

photographs, and Landsat C1 imagery and use them together. The test was comprised of a sequence of four subtests, each of which was designed to measure the children's ability to use the maps noted previously in accordance with the teaching unit. A description of the teaching unit, tests, and maps, will be found in the appendices.

The indirect method of observation was used for Part A of the Map 1 Test while the direct method of observation was used for the rest of the tests. All responses were recorded on each subject's answer sheet. Some tasks required the subject's delineation or marking, and these were recorded with indelible felt pens on the acetate cover of each map.

The sample for the study consisted of six grade four children from an elementary school in the Edmonton Public School system. The sample was composed of four males and two females with abilities in the range of below average, average, and above average for each of two subjects as determined by their teacher.

The RSOATB was administered by the investigator for two days in April, 1982, to each subject in an individual testing situation. Validation of the instrument was established by consultation with two experts in the field of remote sensing education and social studies, and remote sensing.

In addition, the Ishihara Color-Blindness Test was administered to the children by the investigator to provide an assessment

of color vision deficiency. A description of this test procedure and results are given in Appendix C.

Summary of the Findings

The major findings of the study are summarized as follows:

1. The Road Map Test sought to determine the ability of the grade four children in this project to recognize the road map, to orient it, to detect and identify features which may provide secondary ground truth information for subsequent remote sensing interpretation, and to provide initial experience with the aerial perspective.

(a) Results of the Road Map Test indicate that these children are able to recognize directions and orient a road map, identify some geographic features and use their proper names from the road map for identifying these features.

(b) The direct method of observation used in Road Map Test seems appropriate for its interpretation.

(c) The road map appears to be a satisfactory tool for obtaining secondary ground truth information in a multiple map learning strategy.

2. Map 1 Tests were based on a high altitude, small scale color infrared aerial photograph of Calgary. The tests attempted

to find out first, whether grade four children could recognize a CIRVAP and understand how it is made; and second, to determine the ability of grade four children to interpret a high altitude, small scale CIRVAP (Map 1).

(a) It was found that the subjects tested were able to recognize a high altitude, small scale CIRVAP and correctly indicate how this image was made.

(b) The results indicate that the children were able to detect and identify features in the cultural, vegetation and hydrologic categories with no preference for any one category, but this may depend on the site of the image and the number of questions asked in each category.

(c) It would appear that once some basic aerospace and color infrared concepts are understood by the children, the interpretation of the CIRVAP becomes an easier task. Aerospace information provides background about the aircraft, how the photographs are taken, and correspondingly, the spatial resolution and aerial perspective.

(d) Map 1 represented a variety of topographic features of the terrain which seemed to stimulate the interest of the children. It can be implied that CIR vertical aerial photographs bearing a variety of detail may interest children, however, the extent to which children will interpret features will depend on the questions presented.

(e) The results of Map 1 Tests indicate that no one element of map interpretation is used more than the others. It would seem that the recognition of color, shape, patter, size, texture, association, and resolution, used sometimes singularly or in combination with another element facilitate interpretation, but this may be dependent on the question asked.

(f) The direct method of observation, while a selective approach, seems to guide the children to handle progressively difficult interpretation tasks while the non-directed approach used in Map 1 Part A Test seems to provide the opportunity for general appraisal of the site and features.

(g) Factors such as the child's emotion and imagination seem to help the child visualize the aerial perspective, and correspondingly, aid the interpretation of the high altitude, small scale CIRVAP.

(h) The grade four child diagnosed as partially color blind appeared to have no difficulty in the interpretation of a high altitude, small scale CIRVAP.

(i) The way the children scan this CIRVAP seems to influence the number of features they can identify in the non-directed or directed methods of observation.

3. Map 2 Test is based on a low altitude, small scale color infrared vertical aerial photograph of the southwest portion of Calgary. The test had a two-fold design. First, to examine the ability of these children to interpret a low altitude, large scale CIRVAP and give a reason for their identification. Second, to examine the children's ability to use Map 1 and 2 together.

(a) It was found that the grade four children tested were able to interpret a low altitude, large scale CIRVAP, and use it in combination with a high altitude, small scale CIRVAP particularly if their observation is directed.

(b) Size recognition appears more significant than color, shape, pattern, and texture for Map 2 than for Map 1, but this may depend upon the question asked.

(c) Basic aerospace information such as image formation, air-caft flying height, and resolution seems to help the child with understanding the aerial perspective.

(d) An understanding of the IR region of the electromagnetic spectrum, and the CIR concept previously learned for Map 1, seems to help the children determine the spectral signature of cultural, vegetation, physical, and hydrologic features in their interpretation of Map 2. Color cueing from Map 1 to Map 2 seems evident since these maps bear the same color responses.

4. The Landsat C1 Test attempted first, to examine the ability of these children to recognize a Landsat C1 image and determine how it is made, and second, to examine the children's capabilities to interpret a Landsat C1 image of the same site as the CIR verticals and the road map.

(a) The findings indicated that the grade four children tested recognized the satellite image and understood how it is made.

(b) The children were able to identify cultural, physical, vegetation, and hydrological features.

(c) The instantaneous identifiction of some features by name e.g. the city of Calgary, Bow River, and Glenmore Reservoir indicates transference of road map and CIR vertical aerial information to the satellite image.

(d) Prior understanding of the CIR concept and the spectral signature of features from Maps 1 and 2 seem to have been transferred to the interpretation of the Landsat C1 image.

The grade four children in this study were exposed to a variety of map materials and geographic concepts that were new to them, yet they performed at a reasonably satisfactory level. The following additional considerations may also influence the

children's performance in their interpretation of the road map, CIR vertical aerial photographs, and satellite imagery:

1. The teaching and learning materials, and the teacher's background knowledge.

2. The small group learning situation.

3. The progression of learning from aerospace and color infrared information to sequential and multistage map use.

Implications for Curriculum

This study shows the potential for grade 4 children's use of color infrared vertical aerial photographs in conjunction with Landsat C1 imagery and a road map. The implications of this for the social studies are as follows:

1. These maps seem to be of use in the elementary school social studies program for developing children's mapping ability, for the interpretation of micro-scaled environmental features and subsequently, for learning geographic concepts.

2. The interpretation of CIR vertical aerial photographs and Landsat C1 images appears to provide a better real-world approach for learning geographic and environmental concepts than abstract, conventional topographic maps. These materials can be used for developing more awareness and concern for the environment, and the Earth's natural resources.

3. The ability of children to interpret CIR vertical aerial photographs and Landsat C1 images appears to depend on the teacher's back- ground knowledge. Teacher training regarding these items may be significant for pupil learning.

4. Knowledge of aerospace and space activities seems to arouse children's interest and imagination and should be encouraged in the classroom. Because of this, Remote Sensing, Aerospace or Space Education, and Planetary Science might be considered for inclusion in the curriculum.

Suggestions for Further Research

This study examined the abilities of elementary school children to interpret color infrared vertical aerial photographs and use them in conjunction with Landsat C1 images and a road map. If this investigation may be construed as an initial one in the use of these types of maps in a a multistage strategy to map learning, the following suggestions for future research may be considered.

1. A project using a similar multiple map learning strategy as this study but with a larger sample of children so that further generalizations could be made.

2. A project to determine children's map learning ability in a small group instruction compared to a large group.

3. A project using an improved version of the Remote Sensing Oral Achievement Test Battery. For example, the questions could be developed to deal with the three levels of image discrimination: detection, identification, and analysis within each selected category: cultural, physical or geologic, vegetation and hydrologic, thereby making a more powerful instrument.

4. Examining the method used to teach elementary children the following map interpretation elements: color, shape, size, pattern, texture, shadow, site, resolution, and association - for use with color infrared vertical aerial photographs and Landsat C1 imagery. Once these elements are clearly understood there could be more effective instruction about color infrared verticals and satellite images in a multistage sensing approach.

5. A project to determine the knowledge of geographic content gained from the use of small and large scale color infrared vertical photographs, Landsat C1 imagery, and a road map of a rural test site rather than an urban one.

6. A project using a combination of the more recent Landsat Thematic Mapper (TM) imagery with elementary children.

7. The implications of aerospace or space education and planetary science in the elementary school.

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APPENDICES

APPENDIX A

LETTER TO THE PARENTS

Department of Elementary Education,
The University of Alberta,
March, 1982.

Dear ______________________

I am pleased to inform you that your child __________________ has been chosen to participate in a project designed to improve the education of elementary school children. This project is under the supervision of Dr. Joe Kirman.

I am attempting to discover the ability of grade four children using maps made up of a city road map of Alberta, two color infrared vertical aerial photographs and a Landsat C1 image, all of the Alberta region.

This project has been approved by the Edmonton Public School Board and full cooperation by the grade four teacher and the principal. This project will in no way interfere with your child's regular schooling, rather, it may be regarded as an educational experience itself. Only a small amount of time will be required.

The results of tests administered will be held in strictest confidence. It will in no way reflect your child's school learning or school potential and no child will be identified when the results are published.

I hope this letter adequately explains the project conducted and the type of activities your child will be engaged in. Please feel free to contact me at the University (432-3913) or at my residence (435-0443).

Yours truly,

Pearl Gyan

APPENDIX B

TABLE 9 - PROFILE OF IMAGES

TABLE 9
COMPARISON OF IMAGE PROFILES FOR THE CALGARY TEST SITE

Type of Imagery	Scale	Date	Size on Film/Paper	Altitude Above Sea Level (ASL)
Road Map	1:112,640	1980/81	25 cm x 30 cm	
Map 1 (High altitude, small scale CIRVAP).	1:118,000	Aug. 3 1978	24.5 cm x 24 cm	11,286.3 m (37,621 ft.)
Map 2 (Low altitude, large scale CIRVAP). *SW.	1:060,000	Aug. 9 1981	24.5 cm x 24 cm	9,900 m (33,000 ft.)
Landsat C1	1:1,000,000	July 16 1979	23 cm x 23 cm	900 km.

*SW - Southwest coverage of the city of Calgary.

APPENDIX C

COLOR-BLINDNESS TEST

COLOR-BLINDNESS TEST

The Ishihara Test for color-blindness was used to diagnose color vision deficiency in the sample. The test was simplified to an examination of six plates out of the series of twenty-four. This was in accord with the test instruction for testing many patients. Plates 1, 3, 6, 9, 11, 15, and 18 were used. All the subjects in this study were tested by the teacher-investigator. Subject E was subsequently tested by the school nurse at the same time that the test was being administered. All subjects were rated by their teacher as having normal visual acuity. The test was given to all students on the same day (March 18, 1982) at the beginning of the Remote Sensing Teaching Unit.

Test Results

An examination of Table 10 reveals five subjects as having normal color vision. Table 10 also shows that one male subject was diagnosed as having partial color vision deficiency, specifically, a low sensitivity to the red and green parts of the spectrum.

TABLE 10

RESULTS OF THE COLOR-BLINDNESS TEST

Subjects ID Code	Age	Sex	Test Plates							Correct Responses	Color Blind Test Result	Visual Acuity of Teacher Rating
			1	3	6	9	11	15	18			
Plate Readout			12	29	15	45	7	*	18			
Subject A	9.8	F	/	/	/	/	/	/	/	7	0	Normal[a]
Subject D	9.6	M	/	/	/	/	/	/	/	7	0	Normal
Subject C	9.4	M	/	/	/	/	/	/	/	7	0	Normal[a]
Subject E[b]	10.1	M	12	80	11	45	43	91	x	2	**	Normal
Subject B	10.1	F	/	/	/	/	/	/	/	7	0	Normal
Subject F	9.4	M	/	/	/	/	/	/	/	7	0	Normal

/ - Correct Response
a - Subjects wore glasses.
b - Subject was retested by the school nurse on the same day and results were similar as above.
* - Plate 15. The correct response was the inability to recognize any number.
** - Diagnosed as partial color-blindness.
x - Incorrect response.
0 - Normal color vision.

Analysis of Answers

Plates 1, 3, 6, 9, 11, and 15 required subjects to read the numbers within three seconds. On plate 15, the number represented was intended to be undetermined with normal color vision. Its correct response was the inability to recognize any number. Subject E's response to what he saw on Plate 15 was "91." This was incorrect. Plate 18 required subjects to trace winding lines between two x's within ten seconds. Five of the subjects which included two females and three males performed each task correctly. Subject E, a male, read only Plates 1 and 9 correctly. He had further difficulty with Plate 18. He seemed to need more time to trace the lines.

Subject E was subsequently tested by the school nurse immediately after this test was administered. The school nurse used the entire battery of twenty plates. It was found that this child was able to recognize bright shades of pink and green. The school nurse diagnosed Subject E as having partial color-blindness which is described as a low sensitivity to the red and green parts of the visible region of the spectrum. A low sensitivity to color stimuli does not mean any abnormality in the visual functions.

APPENDIX D

THE REMOTE SENSING TEACHING UNIT (RSTU)

THE REMOTE SENSING TEACHING UNIT

Introduction

The Remote Sensing Teaching Unit (RSTU) dealt with the interpretation of a road map, one small and one large scale color infrared vertical aerial photograph and a Landsat C1 image, each representing the Edmonton region. The RSTU required the sample of grade four children to interpret the above maps according to the sequence noted in Table 11, A list of the instructional materials used in this teaching unit will be found in Appendix E.

A science room was provided for the instruction by the principal, and there were usually no interruptions. Upon the classroom teacher's request, the children were at school five minutes earlier every morning so that all sessions started at 8:45 a.m. Each session lasted forty-five minutes and continued for twenty-six days prior to the administration of the Remote Sensing Oral Achievement Test Battery (RSOATB). This test battery will be found in Appendix F.

The children worked in pairs, sharing one map between them to encourage free discussions for understanding concepts and problem solving. Each pair of children were given a map to work with in the sequence given in Table 11. Each map was enclosed in an acetate carboard envelope so that the children could map or draw on them

TABLE 11

TIME DURATION AND SEQUENCE OF THE REMOTE SENSING TEACHING UNIT (RSTU)

	Duration	Remote Sensing Imagery - Edmonton Site	Total Time in Minutes
1.	5 days	City Road Map of Edmonton, Alberta (1980/81)	225
2.	7 days	Map 1, High Altitude, Small scale CIRVAP (August 4, 1974)	315
3.	5 days	Map 2, Low Altitude, Large Scale CIRVAP (June 7, 1977)	225
4.	2 days	Maps 1, 2, and the Road Map	90
5.	5 days	Landsat C1, (July 14, 1974)	225
6.	2 days	Multistage Imagery	90
	26 days		1170 = 19.5 hours

and as well, use the various maps interchangeably. Each child was given a 76 mm magnifying glass and water soluble felt markers to use on the acetate.

Instructional materials (see, Appendix E) and blackboard illustrations provided introductory and background information corresponding to the map that was being taught. The deductive teaching method was used so that the children would be able to recognize and identify features which in turn would lead them to the identification and location of other features, and, to problem solving in the aerial context. To facilitate this frame of reference, specific objectives were developed for the RSTU which would correspond with each map presented in Table 11. These objectives were as follows:

1. To recognize a road map, color infrared vertical aerial photographs, and Landsat C1 imagery.

2. To understand how the CIRVAP and satellite images are formed.

3. To develop a working vocabulary.

4. To understand the color infrared portion of the electromagnetic spectrum and the color infrared concept.

5. To understand the spectral signature of cultural, vegetation, hydrological, and physical features in the CIR verticals and the Landsat C1 image.

6. To detect and identify features in the road map, CIR verticals, and Landsat C1 image.

7. To delineate certain targets for obtaining specific information.

8. To use the road map, CIR vertical aerials, and satellite imagery in a multistage strategy for solving geographic and environmental problems.

For each item in Table 11, the above objectives were followed. In addition, for each map specific objectives and teaching procedures were developed. These are presented as follows.

ACTIVITY 1: USING THE ROAD MAP OF EDMONTON

Objectives

Value: The sample of children will:

a. Become aware of the uses of the road map for orientation and observation of environmental features.

Knowledge: The children will learn:

a. The four cardinal directions.

b. The location of the study site by name.

c. That the identification of cultural, hydrological, and vegetation features provide land cover and land use information.

Skill: The children will:

a. Use a cardinal directions for orientation on a road map.

b. Interpret the road map by identifying cultural, hydrological, or vegetation features.

c. Map the site of Edmonton.

d. Delineate a target area and identify features within it.

e. Observe "land cover" and "land uses."

Materials

1. Road maps of the city of Edmonton.
2. Magnifying glasses.
3. Water soluble felt markers.
4. Rulers.

Procedure

1. General introduction to the road map. Say: This is a road map. It shows a place on the surface of the Earth. Can you tell what place it shows? What is the name of the road map? Tell the children that the road map provides information of a very large site that we are unable to see at once.

Introduce the compass rose on the map and the four cardinal directions: north, south, east, and west. Ask the children to show which way is north, south, east and west on the map.

Print all new words on the blackboard and handle for pronunciation and definition in the usual manner.

Locate on the road map home, school, and other familiar areas. Practise recognizing the directions of these given features from each other e.g. in what direction is Rundle Park from Coronation Park?

2. Locate and outline the city boundary. Identify suburban communities by name and note their directions from home area. Ask and discuss: Are these communities part of the city? Why do the people choose to live there? Could we tell whether the city of Edmonton is growing from the map?

3. Identify familiar cultural, hydrological, and vegetation features by name when possible e.g. U. of A. Campus, Mill Creek, golf course. Have the children locate and practise mapping these features with each category done separately so that the children would become familiar with these terms.

Ask the children to show which features in each category cover a certain area.

4. Say: The road map does not show us pictures of real things. It tells us what real things are through signs and symbols. Have the children identify and interpret some signs and symbols related to cultural, hydrological, and vegetation categories.

This exercise is useful for subsequent aerial and satellite interpretation for land use identification.

Identify major transportation routes, buildings, parks and golf course, creeks, rivers, lakes, and sloughs. Observe and discuss the various elements of shape, pattern, size, color, site that would apply to the interpretation of features, e.g. the shape of the North Saskatchewan River, patterns of streets, highways and railroads, color of water and vegetation areas.

Ask: Have you seen the North Saskatchewan River? What is the color of the water? What color are trees and grass? Discuss the children's perception of features in the real world and what can be seen in the road map.

5. Ask and discuss: How can you tell people live in this site? How does the road map show we use the land? Record answers on the blackboard. Discuss the limitations of the road map to show a variety of land cover and land use data. Have children map a given area, and using the magnifying glass, identify features within this area.

6. For review, orally test each child by presenting direction, identification, and environmental problems: What direction is Fort Edmonton from University farm? Show me Big Lake. Where could there be a building? What two transportation routes are north of the municipal airport? How can you tell the difference between a road and the railway?

ACTIVITY 2: USING MAP 1 (HIGH ALTITUDE, SMALL SCALE CIRVAP OF EDMONTON)

Objectives

Value: The sample of grade four children will:

a. Appreciate the use of aerial photography for providing geographic information of a site on the Earth's surface.

b. Become aware of the IR portion of the electromagnetic spectrum.

c. Appreciate land as a resource.

Knowledge: The children will learn:

a. New vocabulary related to CIR and CIR verticals.

b. How aerial photographs are taken.

c. The spatial distribution of features in aerial photographs.

d. The visible and IR portions of the electromagnetic spectrum, the CIR concept, and the spectral signature of cultural, hydrological, vegetation, and physical features in CIR vertical aerial photographs.

e. Map interpretation skills namely: site, resolution, color, size, shape, shadow, pattern, texture and association.

* f. The definition for "land cover" - the type of features shown on the surface of the Earth; and "land use" - human activities associated with a specific piece of land.

Skill: The children will:

a. Use a road map with a CIRVAP.

* Lillesand and Kiefer, p. 119.

b. Interpret a CIR vertical aerial photograph by using map interpretation skills namely: site, resolution, association, color, size, shape, shadow, texture, and pattern.

c. Detect and identify land cover features.

d. Identify land use features in the cultural, hydrological, and vegetation categories.

e. Delineate certain land cover areas and identify the various land uses within them.

f. Provide solutions for given geographic or environmental problems observed in the CIRVAP.

Materials

1. Slide of a DC-3 aircraft, a commonly used remote sensing and camera platform for aerial photography in Canada.

2. Diagram of the electromagnetic spectrum.

3. Three CIR vertical aerial photographs of the Edmonton region. (Map 1).

4. Magnifying glasses.

5. Water soluble felt markers.

6. Rulers.

7. Road maps of Edmonton.

Procedure

1. List and explain all new words on the blackboard.

2. Present the slide. Explain what aerial photography is about and why it is used. Discuss altitude and spatial resolution to help children understand the spatial detail recorded in images of different scales.

3. Draw a simple diagram of the electromagnetic spectrum on the blackboard. Explain the visible (0.4 - 0.7 μm) and reflected infrared portion (0.7 - 1.1 μm) of the spectrum. In the visible region we can see the sun's energy. In the infrared portion, we cannot see this energy, but it can be photographed with special film or satellite sensing system.

4. Distribute the high altitude, small scale CIRVAP of Edmonton. Have the children recognize the site, its boundary, and locate home, school, and other familiar areas. Use the magnifying glass and have the children detect features of interest. Use the road map and compare the symbols of road map and iconic representation on the CIR aerial. Using the CIRVAP identify prominent cultural, hydrological, and vegetation features, then use the road map to identify by proper name.

5. Explain and write on the blackboard the spectral signature of features in each category: cultural, hydrological and vegetation. Practise identifying targets in each of the above categories using map element clues namely: color, shape, texture, pattern, size, association, shadow. Again, use the road map to identify targets by name.

6. Explain the terms: "land cover" - any type of feature shown on the Earth's surface, and "land uses" - the way we use the land. Identify aspects of various land cover. Then identify land use in the cultural, hydrological and vegetation categories in the

CIRVAP. Delineate an area. Have the children describe the various land uses and observe similar patterns elsewhere on the photograph, using the magnifying glass as needed.

Practise further identification by finding cultural related targets as: The airport, old and new residential areas, downtown, industrial and fringe developments, oil refinery, railways, bridges, roads, school, shopping centers, playgrounds, football fields, stadium, carparks. Children can practise marking each target and comparing them e.g. how can you tell the railway from a road?

7. Practise mapping hydrological features and use with the road map for identifying names: For example:

a. Whitemud Creek.
b. Blackmud Creek.
c. Mill Creek.
d. Sturgeon River.
e. North Saskatchewan River.
f. Big Lake.
g. The pond in the middle of the photograph.

Observe the water southeast of Big Lake and size of Big Lake on the photograph and not on the road map. Provide the dates of each map. Discuss differences, then explain about the flooding that year. Observe the break in Mill Creek on both the photograph and the road map and discuss why.

8. Detect and identify red, pink, and green areas of farmland. Observe the pattern of cropland and golf courses. Discuss land uses related to agriculture. Tell the children what crops are grown. Use the magnifying lens for further perception of agricultural land and other human activities such as the golf courses.

9. Delineate specific target areas within the city area such as: old and new residential areas, fringe developments, city core, commercial services, etc. industries, etc. Compare and contrast these land uses.

Discuss and determine their functions and potentials as applicable. Ask problem solving questions e.g. where would you put a new residential area, a new street, etc. and why? What would happen to farmlands if the city needs to expand?

10. Review by identifying different features in the cultural, hydrological and vegetation categories. Have children give reasons for answers.

ACTIVITY 3: USING MAP 2 (LOW ALTITUDE, LARGE SCALE CIRVAP)

Objectives

Value: The sample of grade four children will:

a. Appreciate the uses of land as a resource.

b. Contribute their experiences regarding consumption and conservation of resources in the natural environment.

<u>Knowledge</u>: The children will learn:

a. The various land uses in an urban area.

b. About the impact of man's activities on the land.

c. That the growth of an urban area has an impact on the natural environment and which may cause conflicts.

<u>Skill</u>: The children will:

a. Interpret a low altitude, large scale CIRVAP.

b. Use elements of map interpretation for identification of features namely: site, association, resolution, size, shape, color, texture, pattern, and shadow.

c. Identify land use in three categories namely: cultural, hydrological, and vegetation.

d. Delineate and identify land cover and land use features within a target area.

e. Solve given geographic problems using the CIRVAP.

<u>Materials</u>

1. Three of Map 2.
2. Magnifying glasses.
3. Water soluble felt markers.
4. Road maps of Edmonton.
5. Rulers.

<u>Procedure</u>

1. Review altitude of aircraft, and resolution by explaining the spatial detail of features from various altitudes.

2. Review the visible and IR regions of the electromagnetic spectrum, and the spectral signature of some features in the cultural, hydrological, and vegetation categories.

3. Let one child in each group of two take a copy of Map 2. Observe the position the children hold the map. If confusion arises, have the children observe prominent features such as the river by shape, pattern, or association. Practise the direction of features by asking: In what direction is Hawrelak's Park from the large loop of the river? The oil refineries from the university?

4. Locate the city center. Ask: How can you tell it is a city? If 'shadows' are mentioned, ask: Which side of the buildings are they? Explain the direction of the sun, time of day, and cardinal directions. Ask: Why do some buildings have shadows and some do not? Have the children identify other tall buildings. Have the children note the differences between shadows and the spectral signature of tops of certain buildings which have an almost black color.

5. Review the spectral signature of features in the three categories: cultural, hydrological, and vegetation. Have the children identify features in each category.

* For the urban areas, detect and identify residential, commer-

* After, Anderson's Land Use and Land Cover Classification System, p. 8.

cial, and services, industries, and transportation areas; for water areas, detect and identify rivers, creeks, lakes, sloughs; for vegetation, detect and identify cropland, pasture, parks, shrubs, lawns and fallow.

6. Select a target site. Have the children delineate this area on the acetate cover of the map. Using their magnifying glass, have the children further identify features in each of the three categories and give a reason. For example: How can you tell a new residential area from an old residential area? How can you tell the industrial area from downtown? How are these categories the same or different? Write the children's responses on the blackboard and discuss their answers.

7. Review the various uses of land e.g. transportation, housing, business, etc. Have the children observe patterns associated with the identification of schools, railroads, old and new residential areas, newly developed areas, playground, football fields, etc.

Discuss environmental and ecological impact upon the land from human uses e.g. pollution, expansion of the city on farmland. Have the children generate viable solutions. Upon the completion of this activity, the children in this study contemplated seeing the mayor of Edmonton concerning these issues. (We were unable to do so).

ACTIVITY 4: USING MAPS 1, 2, AND THE ROAD MAP OF EDMONTON

Objectives

Value: The sample of grade four children will:

a. Evaluate the use of each map.

Knowledge: The children will learn that:

a. Land uses (the way we use the land) change according to the needs of people.

b. Multidate information from CIR vertical aerial photographs helps to monitor man's impact upon the land.

c. Land use changes may cause conflicts.

Skill: The children will:

a. Generate multidate information from a small and large scale CIR aerial photograph.

b. Use the road map in conjunction with the CIR verticals to identify cultural, hydrological, and vegetation features by name.

c. Locate and identify land uses in both CIR verticals and observe patterns of change.

d. Use each map to recognize the function of various land uses and generate solutions for geographic problems.

Materials:

1. A road map of the site of Edmonton for each child.
2. Three of Maps 1 for each two children.
3. Three of Maps 2 as above.

4. Magnifying glasses for each child.
5. Water-soluble felt markers.
6. Rulers.

Procedure

1. Distribute materials and have the children lay the maps in front of them. Provide the date for each map material on the blackboard. Discuss the dates photographs were taken and observe any land use changes.

Using the road map, locate various cultural, hydrologic, and vegetation features e.g. cultural features such as Edmonton Municiple Airport, Southgate Shopping Center, the University of Alberta; locate areas with vegetation e.g. Rundle Park, golf courses, Fort Edmonton Park; locate water areas e.g. Whitemud and Blackmud Creeks.

Have the children identify these targets on both Map 1 and 2. The children can suggest places on the road map, then identify them in both maps. This task becomes not only interesting to them, but useful for subsequent observation of land use patterns and changes.

2. Using Maps 1 and 2, direct the children's attention to locating old and new residential areas. Have the children discriminate each of these areas using one or more map interpretation elements. Have the children use the magnifying glasses for better perception.

Ask: How can you tell the difference between an old residential area and a new residential area? How can you tell warehouses from apartments? Practise identifying targets. For instance, say: Find target "H" on the road map and in Maps 1 and 2.

These activities became an enjoyable game in which more time could have been spent.

3. Have the children locate the southeast portion of the city in all three maps. Ask: Is this area the same as on each map? If not, how is it different? Have the children explain the differences. Discuss the land use changes observed and the significance of multidate information.

Discuss the need for growth of the city and encroachment into farmland. Ask: What will happen to good farmland in the future? Say: If the population increases, where can more roads, businesses, housing, etc. be built?

This problem-solving discussion can lead to various language arts, art, and drama activities. For this study, it was reluctantly stopped at the discussion level. The children's heightened interest with various aspects of land use, was evident from their eagerness to discuss the impact of human activities to the land, and the future of it as a resource. A follow-up through art, drama, or language arts in the classroom situation could provide for the children's creative development.

ACTIVITY 5: USING LANDSAT C1 IMAGERY OF THE EDMONTON SITE

Objectives

Value: The grade four children in the sample will:

a. Become aware of an unmanned Earth resource satellite named "Landsat".

b. Appreciate the uses of Landsat for monitoring the Earth's surface, and providing data which can be used for surveying, assessing recources, and telling global conditions of the Earth.

c. Become aware of a macro scaled region of the environment through the use of Landsat C1 imagery.

Knowledge: The children will learn:

a. The Landsat C1 images are data taken from a very high altitude and cover very large ground areas.

b. That Landsat C1 images represent three wavelength bands: two in the visible portion, green (0.5 - 0.6 μm) and red (0.6 - 0.7 μm), and one in the invisible IR portion (0.8 - 1.100 μm). The resulting images resemble CIR vertical aerial photographs in their color coding arrangement.

c. The land cover types in this area, and the distribution and location of land uses such as agricultural, urban, water, rangeland, and transportation areas.

d. Where a non-renewable resource such as coal is located, and its present-day uses.

Skill: The children will:

a. Interpret Landsat imagery by detecting and identifying cultural, hydrologic, vegetation, and physical features.

b. Delineate and identify features within a target area, and use a magnifying glass to aid further identification.

c. Use the road map of Alberta to name specific items.

d. Identify ways the satellite image can be used to solve geographic or environmental problems.

Materials

1. Slides of:

a. Landsat 1 prior to its 1972 launch. Landsat 1 was used for early Landsat images.

b. Artist's conception of Landsat over Canada and transmitting image data to the Prince Albert satellite station.

c. Space Shuttle 'Enterprise', a remote sensing platform of the near future.

* 2. Picture booklets of Landsat, one for each child.

3. Three Landsat C1 images of the Edmonton region.

4. Magnifying glasses.

5. Water-soluble felt markers.

6. Road maps of Alberta.

7. Map of Canada.

Procedure

1. Inform children that in this unit they are going to use a satellite image to study a very large ground area of Alberta.

Write all new or difficult words on the blackboard and explain.

* The Picture booklet consisted of four pages, two of which were pictures of Landsat taken from NASA, Landsat, (John. F. Kennedy Space Center: U.S. GPO. 1981 - 640 192/5454), pp. 2, 11. The other two pages were information about Landsat written for the children, by the investigator.

Elicit from the children their knowledge about satellites and their uses.

Present the slides, explaining each one to the children.

Distribute the picture-booklets of Landsat. Read from it to the children and explain: Landsat's coverage of the Earth, Landsat's orbit, and its multispectral scanning system.

On a map of Canada, locate the receiving stations at Shoe Cove, Newfoundland, and Prince Albert, Saskatchewan. Briefly explain the transmission of data from the satellite to the receiving station.

Review the visible and IR regions of the electromagnetic spectrum. Explain the differences between CIR vertical aerial photographs and Landsat C1 images as being data from different altitudes, of which the aerial data is recorded on CIR film, while the C1 images are composite images made from MSS Bands 4, 5, and 7 of the spectrum.

Present the Landsat C1 images to the children. Briefly explain some of the information in the annotated block of the image.

2. Review the spectral signature of cultural, hydrologic, and vegetation features. Detect and identify some of these features on the image and ask how they can tell. Identify the city of Edmonton and also ask how they can tell. Write answers on the blackboard. Practise identifying as many features in each category, with the children explaining their answers.

3. Have the children outline the site of the image on the road map of Alberta. With the two maps side-by-side, have the children locate specific features in each category by name when possible e.g.

a. Cultural - Edmonton and other cities, highways, airport, suburbs adjacent to Edmonton.

b. Hydrologic - Rivers, lakes, sloughs, clear and sedimented water.

c. Vegetation - Agricultural farmlands, and fallow fields.

d. Physical - Dinosaur Park region, the Battle River area for coal management, and pattern of lakes. Note pattern and explain the effects of glaciation.

Use the magnifying glasses and have the children describe the above features from this view.

4. Review by identifying features in each category using the Landsat C1 image. Ask the children to describe the land cover, and the land uses. Write answers on the board to compare land cover and land use. Determine and discuss renewable and/or non-renewable resources in the area.

Elicit various kinds of industries e.g. grain-growing, tourism, winter and summer sports, coal mining, livestock, fishing etc. Discuss their contribution to the economy of the province, and accessibility to major urban area (blue-grey areas) observed on the image.

5. Provide solutions to varying problems:

   a. Locate the international airport. Ask: Why is it located in nearby Leduc?

   b. Where would you build another city or major highway? Why?

   c. Where would you expand Edmonton if you had to? Why?

   d. Discuss optimum use of the land and devise ways of conserving renewable or non-renewable resources identified earlier.

ACTIVITY 6: USING THE MULTISTAGE STRATEGY WITH THE ROAD MAP, CIR VERTICALS, AND LANDSAT C1 IMAGERY OF THE EDMONTON SITE

Objectives

Values: The children will become:

a. Aware that multistage remote sensing imagery can be used to examine an area in both macro and micro scale.

b. Appreciate the use of multidate information for land cover and land use assessment.

Knowledge: The children will:

a. Learn that various maps can be used for land cover and land use mapping.

* b. Review that: "land cover relates to the type of feature present on the surface of the Earth.

* c. Review that: "land use relates to the human activities associated with a specific piece of land."

* Lillesand and Kiefer, p. 119.

d. Learn that multistage remote sensing imagery can be used to solve geographic and environmental problems and vice versa.

Skill: The children will:

a. Examine geographic information from the combined use of a road map, aircraft, and satellite data.

b. Recognize the landscape in each map.

c. Delineate a target in each map, determine its land cover, identify features and assess its land uses.

d. Use the maps interchangebly for solving geographic problems.

Materials

1. Road maps of Edmonton, one for each child.
2. Three of Maps 1 (high altitude, small scale CIRVAP of the Edmonton Region).
3. Three of Maps 2 (low altitude, large scale CIRVAP of Edmonton.)
4. Three Landsat C1 images of the Edmonton area.
5. Magnifying glasses for each child.
6. Water-soluble felt markers.
7. Rulers.

Procedure

1. Using the satellite image first, identify and locate the city of Edmonton. Have the children give reasons for their identification e.g. How can you tell it is Edmonton?

Using the Landsat and Map 1 images, compare the site of Edmonton, then locate some targets on the satellite image e.g. North Saskatchewan River, Mill Creek, downtown, etc. For Map 1, ask: On which image can the features be better seen? Why? Use the road map for identification of proper names of features.

2. Locate Big Lake on the satellite image and on Map 1. Use magnifying glasses for better perception. Observe and describe any differences giving reasons. Explain the flooding of Big Lake in 1974 and have them observe the color of sedimented water.

3. Using Map 2 in conjunction with Map 1 and Landsat, have the children select a target and delineate this area on each map. Discuss the areal variation, identify features in the categories of: cultural, hydrological, and vegetation. Have the children assess the distribution and quantity of land uses.

4. Using each map, have children describe what they would use it for in learning about the environment and why. Write their answers on the blackboard.

5. Present the following problems to the children. Which map would you use:

a. To develop spatial awareness of the environment near their school?

b. To make a land use inventory of the city of Edmonton.

c. To assess the distribution of land resources.

Have the children give reasons for their choice of maps.

6. Have the children observe a few targets on the Landsat image. Ask: Which other map would you use to find out more about each target? Have the children give reasons for their choice of maps.

At the end of the RSTU and the RSOATB, the children in the sample, the classroom teacher, and the investigator went on a field trip to the Alberta Remote Sensing Center in Edmonton for a guided tour. The children, especially some of the boys were very interested. They all seemed to have had an enjoyable experience looking at other Landsat images and the various equipment, and asking questions. One child asked to see a real Landsat satellite. Since this could not be done, a large size photograph of Landsat was shown.

APPENDIX E

MATERIALS USED IN THE REMOTE SENSING TEACHING UNIT

MATERIALS USED IN THE REMOTE SENSING TEACHING UNIT (RSTU)

1. * Slides of:

a. A DC-3 aircraft (Government of Canada). This is a commonly used remote sensing (camera) platform for aerial photographs.

b. Landsat 1 prior to its 1972 launch. Landsat 1 was earlier used for Landsat images. It is now retired.

c. Artist conception of Landsat imaging over Canada and transmitting image data to the Prince Albert satellite station, Saskatchewan.

d. The space shuttle "Enterprise" - One of the series of space shuttles. They are equipped with multispectral and radar imaging facilities. (NASA. OSTA - 1 Experiments, pp. 1 - 10).

2. A Landsat booklet developed by the investigator. It consisted of two pictures of Landsat 1 and some brief information about it. (NASA. LANDSAT, pp. 2 and 11).

3. An illustration of the Electromagnetic spectrum. (A NASA Publication Fact Sheet. NASA ASA-79-4).

4. 1980/81 Road Map of Alberta and Edmonton; A high altitude, small scale (Aug., 4, 1974), and low altitude, large scale (June 7, 1977) CIR vertical aerial photographs of Edmonton; Landsat C1 imagery of Edmonton (July 14, 1974).

* These slides were loaned by the Alberta Remote Sensing Center, Edmonton, Alberta.

APPENDIX F

REMOTE SENSING ORAL ACHIEVEMENT TEST BATTERY (RSOATB) AND ANSWERS

THE ROAD MAP TEST AND ANSWERS

Questions	Answers
1. What is this?	A road map.
2. What place does it show?	The city of Calgary.
3. Show north.	Top of map.
4. Show south.	Bottom of map.
5. Show east.	Right hand side of map.
6. Show west.	Left hand side of map.
7. Outline the boundary of the city of Calgary.	Delineates yellow border on map.
8. Show a body of water.	Points to Glenmore Reservoir.
9. What is its name?	Glenmore Reservoir.
10. Show a river.	Points to Bow or Elbow River on map.
11. What is its name?	Bow or Elbow River.

MAP 1 PART A TEST AND ANSWERS

Questions	Answers
1. What is this?	A color infrared vertical aerial photograph.
2. By what was it made?	An airplane.
3. What season of the year is it?	Summer.
4. How can you tell?	Color of vegetation e.g. crops are red.
5. Name 5 things you see on the map.	Any targets from:
	1. Cultural features e.g. residential areas, roads, industries;
	2. Physical features e.g. bare soil, trees, farmland, hills;
	3. Hydrological features e.g. lake, rivers, sloughs;
	4. Vegetational features e.g. trees, golf courses, parks, grounds.

MAP 1 PART B TEST AND ANSWERS

Questions	Answers
1. What place does this aerial photograph show?	The city of Calgary.
2. How can you tell?	By shape, site, association, pattern.
3. Outline the city of Calgary.	Delineates, boundary of city.
4. What is this area outside the city?	Farmland.
5. How can you tell?	By color, shape, pattern, texture.
6. Outline the Glenmore Reservoir.	Delineates large water body in the foreground.
7. Is its water clear or sedimented?	Clear.
8. How can you tell?	The color appears black.
9. Show the Bow River.	Points to a target on the map.
10. Is its water clear or sedimented?	Both, clear and sedimented.
11. All of it?	No.
12. How can you tell?	Some parts are black to light blue.
13. Outline the Bow River.	Delineates this target on the map.
14. What is "X"?	Airport.

MAP 1 PART B TEST AND ANSWERS

Questions	Answers
15. How can you tell?	Pattern of runway, shape, association.
16. What is "G"?	Commercial services, e.g. industries, warehouses.
17. How can you tell?	By size, shape, pattern, color, texture, association.
18. Find an old residential area. (Marked by a red square).	Delineates target on map.
19. How can you tell?	Linear patterns, texture, size, shape, color, vegetation.
20. Find new residential area. (Marked by an orange square).	Delineates target on map.
21. How can you tell?	Crescent pattern of streets, larger size of dwellings, color, and texture.
22. What is "M"?	Road (Trans Canada Highway).
23. How can you tell?	Linear pattern, size, shape, color.
24. What is "L"?	Golf course.
25. How can you tell?	Color, shape, pattern, texture, association.

MAP 1 PART B TEST AND ANSWERS

	Questions	Answers
26.	What is "O"?	A stand of trees.
27.	How can you tell?	Color, pattern, texture, shape.
28.	What is "Q"?	Downtown (city center).
29.	How can you tell?	Size, shadows, pattern, shape, color.
30.	What is "S"?	Railroad tracks.
31.	How can you tell?	Pattern, shape, color, texture.

MAP 2 TEST AND ANSWERS

Questions	Answers
1. Compare Maps 1 and 2. Show me where this (W) area is on Map 2 as on Map 1.	Points to 'West' target on Map 1.
2. What direction is it from the rest of the city?	West.
3. What is "T"?	Single homes.
4. What is "V"?	Apartments.
5. How can you tell the difference?	By size,shape,pattern,association, and/or texture.
6. What is "C"?	School and schoolyard.
7. How can you tell?	Size, pattern, association, shape, color.
8. Mark a "C" at another school.	Any similar target on the map.
9. Show downtown.	Points on target.
10. Mark a square to show part of downtown.	Delineates target.
11. What kinds of buildings do you see?	Tall buildings, highrises, skyscrapers.
12. How can you tell?	By shadows, shape, size, association.
13. What time of day is it?	Morning.

MAP 2 TEST AND ANSWERS

	Questions	Answers
14.	How can you tell?	The direction of shadows.
15.	Compare Maps 1 and 2. What do you observe with the west portion of the city?	Map 2 target area is larger than Map 1.
16.	What changes do you see?	Land cover changes, land use for residential or industrial development.

LANDSAT C1 TEST AND ANSWERS

Questions	Answers
1. What is this?	A Landsat C1 image.
2. By what was it made?	A satellite.
3. What season of the year is it?	Summer.
4. How can you tell?	Crops and healthy vegetation appear red.
5. What is this area called?	The city of Calgary.
6. How can you tell?	Shape similar as in the road map and the CIR aerials.
7. Show other towns.	Identified by distinctive color and shape.
8. How can you find out the names of these other towns?	Using the road map.
9. Show the Bow River.	Points to a target on the map.
10. What can you tell me about the water in the Bow River?	The water looks clear.
11. How can you tell?	The black color.
12. What is "A"?	Clouds.
13. How can you tell?	Color and texture.

LANDSAT C1 TEST AND ANSWERS

	Questions	Answers
14.	What is "C"?	Lake or slough.
15.	What is "D"?	Cloud shadow.
16.	How can you tell?	Similar shape of cloud.
17.	Show the Glenmore Reservoir.	Identifies target on the map.
18.	What river flows into the Glenmore Reservoir?	Elbow River.
19.	Outline where the Bow River starts.	From the lake or mountain area.
20.	Show where there are mountains.	Identifies area.
21.	How can you tell?	By color, texture, pattern, shadow, shape, and size.
22.	Show an area that looks like snow.	Glaciers.
23.	How can you tell it's snow (glaciers) and not clouds?	Texture, association, pattern, shape, no shadows, size.
24.	Show an area in the mountains with no snow.	Any reasonable target area.
25.	Why would an area in the mountains have snow and another area not have snow?	Higher altitude, position away from the sun, not much melting, shape of mountain to facilitate accumulation of snow.

LANDSAT C1 TEST AND ANSWERS

Questions	Answers
26. Circle an area of thick vegetation that is not farmland.	A reasonable target area.
27. How can you tell there are forests in this area?	By identifying correct color.
28. Mark an area of forests.	A reasonable target area.
29. What is this checkered area?	Lumbering.
30. Draw a line to show where the mountains end.	Correctly delineated at the investigator's discretion.
31. Draw a line to show where the forests end.	As above.
32. What do you call these three regions?	Mountains, foothills, prairies.

APPENDIX G

PLATES OF THE CALGARY TEST SITE

PLATE 1

ROAD MAP OF CALGARY (1980/81)
(The compass rose was erased for the test)

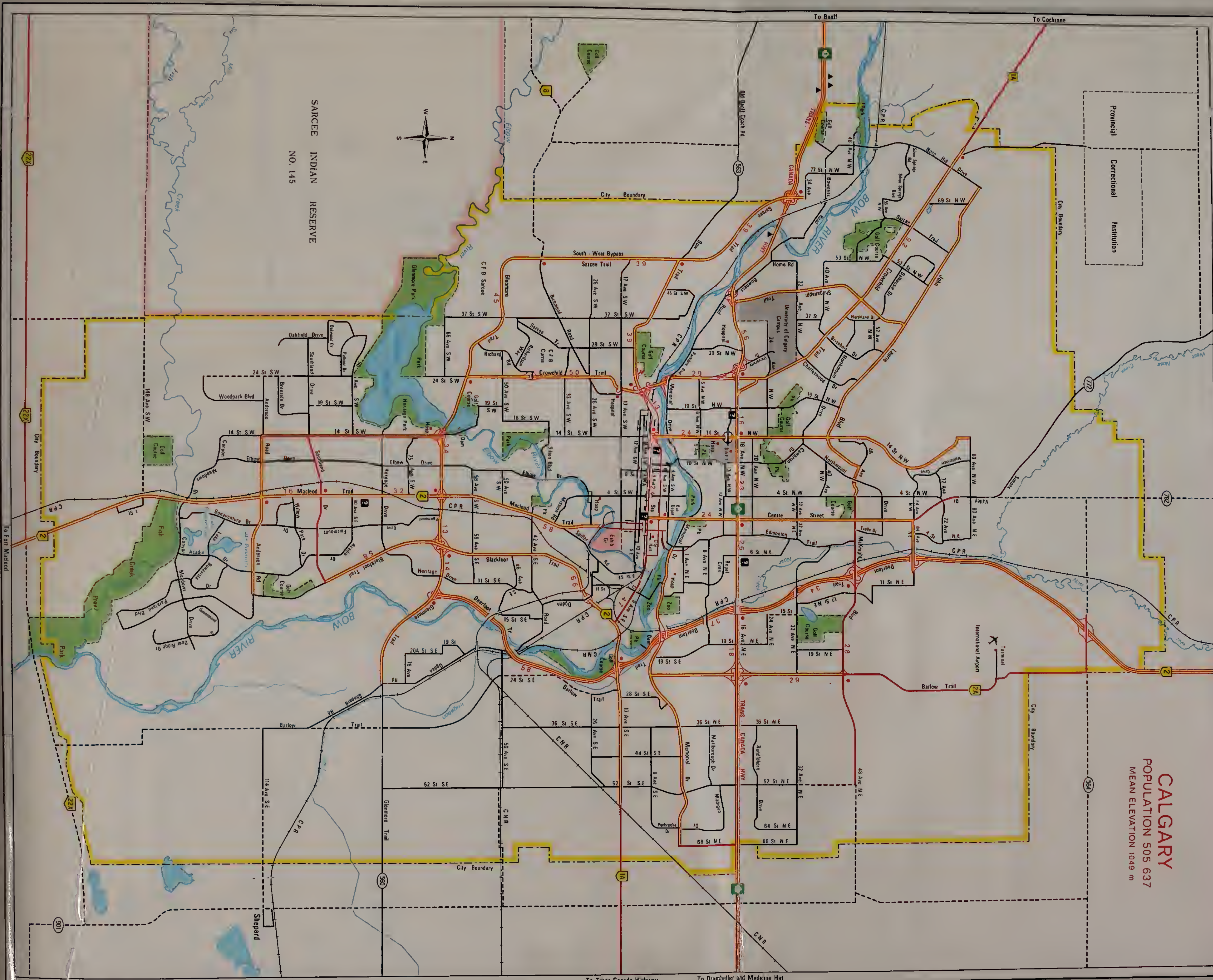
CALGARY
POPULATION 505 637
MEAN ELEVATION 1049 m
SARCEE INDIAN RESERVE NO. 145
Provincial Correctional Institution
To Banff
To Cochrane
To Red Deer and Edmonton
To Drumheller and Medicine Hat
To Trans-Canada Highway
To Fort Macleod
BOW RIVER
Elbow River
City Boundary
International Airport
University of Calgary Campus
Shepard

PLATE 2

MAP 1: The high altitude, small scale (1:118,000) CIRVAP of Calgary (Aug. 3, 1978) reproduced and reduced from its actual size (24.5 cm x 24 cm) to 19.5 cm x 19 cm.

The actual size (24.5 cm x 24 cm) was used in the study.

Plate 2

Map 1: CIRVAP of Calgary

PLATE 3

MAP 2: The low altitude, large scale (1:060,000) CIRVAP of SW Calgary (August 9, 1981) reproduced and reduced from its actual size (24.5 cm x 24 cm) to 19.5 cm x 19 cm.

The actual size (24.5 cm x 24 cm) was used in the study.

Plate 3

Map 2: CIRVAP of SW Calgary

PLATE 4

LANDSAT C1 image of Calgary (July 16, 1979)
at a scale of 1:1,000,000.

It is reproduced and reduced from its actual
size of (23 cm x 23 cm) to 19.3 cm x 19.3 cm.

The actual size (23 cm x 23 cm) was used
in the study.

Plate 4

Landsat C1 Image of the Calgary Area